WEST

Freeform Search

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Term: 118 and (plane)

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Search History

Today's Date: 10/31/2001

DB Name	Query	Hit Count	Set Name
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l19 and (plate)	3	L20
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l18 and (plane)	15	L19
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l17 not l9	18	L18
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l16 and (disposed or located)	19	L17
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l15 and (radi$5)	19	L16
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l14 and (coupl$5)	21	L15
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l5 and (plurality with antenna)	23	L14
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l12 and (radi$5)	4	L13
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l11 and (coupl$5)	4	L12
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l10 and (connect$5)	5	L11
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l9 and (plane)	5	L10
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l8 and (plate)	7	L9
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l7 and (parallel)	24	L8
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l6 and (linear$4)	33	L7
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l5 and (branch$4)	50	L6
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l4 and (ring or loop or anul$4)	178	L5
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l3 and (end)	263	L4
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l2 and (ground)	330	L3
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	l1 and (antenna)	1712	L2
USPT,PGPB,JPAB,EPAB,DWPI,TDBD	((magnetic adj resonance) or MRI or NMR)	120558	L1

WEST

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Search Results - Record(s) 1 through 5 of 5 returned.

☐ 1. Document ID: US 6005916 A

L11: Entry 1 of 5 File: USPT Dec 21, 1999

US-PAT-NO: 6005916
DOCUMENT-IDENTIFIER: US 6005916 A

TITLE: Apparatus and method for imaging with wavefields using inverse scattering techniques

DATE-ISSUED: December 21, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Johnson; Steven A.	Salt Lake City	UT		
Borup; David T.	Salt Lake City	UT		
Wiskin; James W.	Salt Lake City	UT		
Natterer; Frank	Muenster			DEX
Wubeling; F.	Muenster			DEX
Zhang; Yongzhi	Madison	WI		
Olsen; Scott Charles	Salt Lake City	UT		

US-CL-CURRENT: 378/87; 378/98, 600/425, 600/437

Full | Title | Citation | Front | Review | Classification | Date | Reference | KWIC | Draw Desc | Image

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☐ 2. Document ID: US 5764518 A

L11: Entry 2 of 5 File: USPT Jun 9, 1998

US-PAT-NO: 5764518
DOCUMENT-IDENTIFIER: US 5764518 A

TITLE: Self reproducing fundamental fabricating machine system

DATE-ISSUED: June 9, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Collins; Charles M.	Burke	VA	22015	

US-CL-CURRENT: 700/95; 700/117

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 3. Document ID: US 5304214 A

L11: Entry 3 of 5   File: USPT   Apr 19, 1994

US-PAT-NO: 5304214
DOCUMENT-IDENTIFIER: US 5304214 A

TITLE: Transurethral ablation catheter

DATE-ISSUED: April 19, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
DeFord; John A.	Lafayette	IN		
Ely; Joseph F.	West Lafayette	IN		
Fearnot; Neal E.	West Lafayette	IN		

US-CL-CURRENT: 607/105; 604/916, 607/113

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 4. Document ID: US 5200701 A

L11: Entry 4 of 5   File: USPT   Apr 6, 1993

US-PAT-NO: 5200701
DOCUMENT-IDENTIFIER: US 5200701 A

TITLE: Magnetic resonance imaging apparatus with regulator for reducing eddy current effects

DATE-ISSUED: April 6, 1993

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Siebold; Horst	Erlangen			DEX
Oppelt; Ralph	Weiher			DEX
Ries; Guenter	Erlangen			DEX

US-CL-CURRENT: 324/309; 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 5. Document ID: US 5020411 A

L11: Entry 5 of 5   File: USPT   Jun 4, 1991

US-PAT-NO: 5020411
DOCUMENT-IDENTIFIER: US 5020411 A

TITLE: Mobile assault logistic kinetmatic engagement device

DATE-ISSUED: June 4, 1991

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Rowan; Larry	Culver	CA	90230	

US-CL-CURRENT: 89/1.11; 376/319, 60/203.1, 89/8

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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Term	Documents
CONNECT$5	0
CONNECT.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1190227
CONNECTA.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	12
CONNECTAABLE.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1
CONNECTAB.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	4
CONNECTABALE.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1
CONNECTABE.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	3
CONNECTABEL.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	3
CONNECTABIE.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1
CONNECTABIL.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	2
(L10 AND (CONNECT$5)).USPT,PGPB,JPAB,EPAB,DWPI,TDBD.	5

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Search Results - Record(s) 1 through 4 of 4 returned.

☐ 1. Document ID: US 6005916 A

L13: Entry 1 of 4 File: USPT Dec 21, 1999

US-PAT-NO: 6005916
DOCUMENT-IDENTIFIER: US 6005916 A

TITLE: Apparatus and method for imaging with wavefields using inverse scattering techniques

DATE-ISSUED: December 21, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Johnson; Steven A.	Salt Lake City	UT		
Borup; David T.	Salt Lake City	UT		
Wiskin; James W.	Salt Lake City	UT		
Natterer; Frank	Muenster			DEX
Wubeling; F.	Muenster			DEX
Zhang; Yongzhi	Madison	WI		
Olsen; Scott Charles	Salt Lake City	UT		

US-CL-CURRENT: 378/87; 378/98, 600/425, 600/437

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw Desc | Image

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☐ 2. Document ID: US 5764518 A

L13: Entry 2 of 4 File: USPT Jun 9, 1998

US-PAT-NO: 5764518
DOCUMENT-IDENTIFIER: US 5764518 A

TITLE: Self reproducing fundamental fabricating machine system

DATE-ISSUED: June 9, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Collins; Charles M.	Burke	VA	22015	

US-CL-CURRENT: 700/95; 700/117

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw. Desc | Image

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☐ 3. Document ID: US 5304214 A

L13: Entry 3 of 4 File: USPT Apr 19, 1994

US-PAT-NO: 5304214
DOCUMENT-IDENTIFIER: US 5304214 A

TITLE: Transurethral ablation catheter

DATE-ISSUED: April 19, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
DeFord; John A.	Lafayette	IN		
Ely; Joseph F.	West Lafayette	IN		
Fearnot; Neal E.	West Lafayette	IN		

US-CL-CURRENT: 607/105; 604/916, 607/113

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

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☐ 4. Document ID: US 5020411 A

L13: Entry 4 of 4 File: USPT Jun 4, 1991

US-PAT-NO: 5020411
DOCUMENT-IDENTIFIER: US 5020411 A

TITLE: Mobile assault logistic kinetmatic engagement device

DATE-ISSUED: June 4, 1991

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Rowan; Larry	Culver	CA	90230	

US-CL-CURRENT: 89/1.11; 376/319, 60/203.1, 89/8

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

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Term	Documents
RADI$5	0
RADI.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	636
RADIA.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	693
RADIAAL.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	4
RADIAALLY.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1
RADIAALS.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1
RADIAALY.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1
RADIAATED.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1
RADIABI.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	2
RADIABLE.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	17
(L12 AND (RADI$5)).USPT,PGPB,JPAB,EPAB,DWPI,TDBD.	4

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Search Results - Record(s) 1 through 23 of 23 returned.

☐ 1. Document ID: US 6255817 B1

L14: Entry 1 of 23 File: USPT Jul 3, 2001

US-PAT-NO: 6255817
DOCUMENT-IDENTIFIER: US 6255817 B1

TITLE: Nuclear magnetic resonance logging with azimuthal resolution

DATE-ISSUED: July 3, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Poitzsch; Martin E.	Sugar Land	TX		
Speier; Peter	Stafford	TX		
Ganesan; Krishnamurthy	Sugar Land	TX		
Chang; Shu-Kong	Sugar Land	TX		
Goswami; Jaideva C.	Houston	TX		

US-CL-CURRENT: 324/303; 324/300

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 2. Document ID: US 6249252 B1

L14: Entry 2 of 23 File: USPT Jun 19, 2001

US-PAT-NO: 6249252
DOCUMENT-IDENTIFIER: US 6249252 B1

TITLE: Wireless location using multiple location estimators

DATE-ISSUED: June 19, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Dupray; Dennis J.	Denver	CO		

US-CL-CURRENT: 342/450; 342/357.01, 342/457

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 3. Document ID: US 6246898 B1

L14: Entry 3 of 23 File: USPT Jun 12, 2001

US-PAT-NO: 6246898
DOCUMENT-IDENTIFIER: US 6246898 B1

TITLE: Method for carrying out a medical procedure using a three-dimensional tracking and imaging system

DATE-ISSUED: June 12, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vesely; Ivan	Cleveland Heights	OH		
Smith; Wayne	London			CAX
Klein; George	London			CAX
Burkhoff; Daniel	Tenafly	NJ		

US-CL-CURRENT: 600/424; 600/429, 600/439, 606/130

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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4. Document ID: US 6229310 B1

L14: Entry 4 of 23   File: USPT   May 8, 2001

US-PAT-NO: 6229310
DOCUMENT-IDENTIFIER: US 6229310 B1

TITLE: Magnetic resonance imaging excitation and reception methods and apparatus

DATE-ISSUED: May 8, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Green; Charles	Holbrook	NY		
Votruba; Jan	Ridge	NY		
Eydelman; Gregory	West Hempstead	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 324/318; 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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5. Document ID: US 6136274 A

L14: Entry 5 of 23   File: USPT   Oct 24, 2000

US-PAT-NO: 6136274
DOCUMENT-IDENTIFIER: US 6136274 A

TITLE: Matrices with memories in automated drug discovery and units therefor

DATE-ISSUED: October 24, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Nova; Michael P.	Rancho Santa Fe	CA		
Lillig; John E.	Poway	CA		
Karunaratne; Kanchana Sanjaya Gunesekera	San Diego	CA		
O'Neil; Donald	San Diego	CA		
Ewing; William	San Diego	CA		
Satoda; Yozo	San Diego	CA		

US-CL-CURRENT: 422/102; 422/101, 422/104, 435/288.4, 435/288.5, 435/297.1, 435/303.1, 435/305.2

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 6. Document ID: US 6056744 A

L14: Entry 6 of 23   File: USPT   May 2, 2000

US-PAT-NO: 6056744
DOCUMENT-IDENTIFIER: US 6056744 A

TITLE: Sphincter treatment apparatus

DATE-ISSUED: May 2, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Edwards; Stuart D.	Portola Valley	CA		

US-CL-CURRENT: 606/41; 607/101

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 7. Document ID: US 6017496 A

L14: Entry 7 of 23   File: USPT   Jan 25, 2000

US-PAT-NO: 6017496
DOCUMENT-IDENTIFIER: US 6017496 A

TITLE: Matrices with memories and uses thereof

DATE-ISSUED: January 25, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Nova; Michael P.	Santa Fe	CA		
Parandoosh; Zahra	San Diego	CA		
Senyei; Andrew E.	La Jolla	CA		
Xiao; Xiao-Yi	San Diego	CA		
David; Gary S.	La Jolla	CA		
Satoda; Yozo	San Diego	CA		
Zhao; Chanfeng	San Diego	CA		
Potash; Hanan	La Jolla	CA		

US-CL-CURRENT: 422/68.1; 422/102, 422/104, 422/107, 422/108, 422/50, 422/58, 422/99, 435/6, 435/7.1, 702/22

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

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☐ 8. Document ID: US 5967986 A

L14: Entry 8 of 23   File: USPT   Oct 19, 1999

US-PAT-NO: 5967986
DOCUMENT-IDENTIFIER: US 5967986 A

TITLE: Endoluminal implant with fluid flow sensing capability

DATE-ISSUED: October 19, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Cimochowski; George E.	Dallas	PA		
Keilman; George W.	Woodinville	WA		

US-CL-CURRENT: 600/454; 600/504, 600/505

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

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☐ 9. Document ID: US 5939883 A

L14: Entry 9 of 23   File: USPT   Aug 17, 1999

US-PAT-NO: 5939883
DOCUMENT-IDENTIFIER: US 5939883 A

TITLE: Magnetic resonance imaging excitation and reception methods and apparatus

DATE-ISSUED: August 17, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Green; Charles	Holbrook	NY		
Votruba; Jan	Ridge	NY		
Eydelman; Gregory	West Hempstead	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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10. Document ID: US 5751600 A

L14: Entry 10 of 23   File: USPT   May 12, 1998

US-PAT-NO: 5751600
DOCUMENT-IDENTIFIER: US 5751600 A

TITLE: Method and apparatus for the analysis of electromagnetics

DATE-ISSUED: May 12, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Ochi; Hisaaki	Tokyo			JPX
Yamamoto; Etsuji	Tokyo			JPX
Sawaya; Kumio	Sendai			JPX
Adachi; Saburo	Sendai			JPX

US-CL-CURRENT: 702/64; 343/703

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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11. Document ID: US 5697958 A

L14: Entry 11 of 23   File: USPT   Dec 16, 1997

US-PAT-NO: 5697958
DOCUMENT-IDENTIFIER: US 5697958 A

TITLE: Electromagnetic noise detector for implantable medical devices

DATE-ISSUED: December 16, 1997

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Paul; Patrick J.	Lake Jackson	TX		
Prutchi; David	Lake Jackson	TX		

US-CL-CURRENT: 607/31; 128/901, 607/32, 607/60

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 12. Document ID: US 5530351 A

L14: Entry 12 of 23   File: USPT   Jun 25, 1996

US-PAT-NO: 5530351
DOCUMENT-IDENTIFIER: US 5530351 A

TITLE: NMR tomography apparatus with combined radio frequency antenna and gradient coil

DATE-ISSUED: June 25, 1996

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Moritz; Michael	Mistelgau			DEX
Pausch; Guenther	Effeltrich			DEX

US-CL-CURRENT: 324/309; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 13. Document ID: US 5402788 A

L14: Entry 13 of 23   File: USPT   Apr 4, 1995

US-PAT-NO: 5402788
DOCUMENT-IDENTIFIER: US 5402788 A

TITLE: Diagnostic system using nuclear magnetic resonance phenomenon

DATE-ISSUED: April 4, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Fujio; Koji	Tokyo			JPX
Gotanda; Masakazu	Kanagawa			JPX
Yamaguchi; Tatsuya	Tokyo			JPX
Takayama; Shuichi	Tokyo			JPX
Tsukaya; Takashi	Tokyo			JPX
Hagiwara; Toshihiko	Tokyo			JPX
Matsui; Koichi	Tokyo			JPX
Hibino; Hiroki	Tokyo			JPX
Hiyama; Keiichi	Tokyo			JPX
Shimizu; Koichi	Tokyo			JPX
Yoshino; Kenji	Tokyo			JPX
Hayashi; Masaaki	Tokyo			JPX

US-CL-CURRENT: 600/423

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 14. Document ID: US 5396174 A

L14: Entry 14 of 23   File: USPT   Mar 7, 1995

US-PAT-NO: 5396174
DOCUMENT-IDENTIFIER: US 5396174 A

TITLE: Antenna arrangement with shielding for a nuclear magnetic resonance tomography apparatus

DATE-ISSUED: March 7, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hanke; Wilhelm	Rueckersdorf			DEX
Morita; Michael	Mistelgau			DEX
Freisen, deceased; Ludger	late of Erlangen			DEX

US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 15. Document ID: US 5351688 A

L14: Entry 15 of 23   File: USPT   Oct 4, 1994

US-PAT-NO: 5351688
DOCUMENT-IDENTIFIER: US 5351688 A

TITLE: NMR quadrature detection solenoidal coils

DATE-ISSUED: October 4, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Jones; Randall W.	Bellevue	NE		

US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 16. Document ID: US 5284144 A

L14: Entry 16 of 23   File: USPT   Feb 8, 1994

US-PAT-NO: 5284144
DOCUMENT-IDENTIFIER: US 5284144 A

TITLE: Apparatus for hyperthermia treatment of cancer

DATE-ISSUED: February 8, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Delannoy; Jose	Monsen Baroeul			FRX
Le Bihan; Denis	Rockville	MD		
Chen; Ching-nien	Catonsville	MD		
Levin; Ronald L.	Olney	MD		
Turner; Robert	Bethesda	MD		

US-CL-CURRENT: 600/412; 324/315, 600/422, 607/154

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 17. Document ID: US 5050605 A

L14: Entry 17 of 23   File: USPT   Sep 24, 1991

US-PAT-NO: 5050605
DOCUMENT-IDENTIFIER: US 5050605 A

TITLE: Magnetic resonance imaging antennas with spiral coils and imaging methods employing the same

DATE-ISSUED: September 24, 1991

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Eydelman; Gregory	West Hempstead	NY		
Giambalvo; Anthony	Kings Park	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 18. Document ID: US 5041788 A

L14: Entry 18 of 23   File: USPT   Aug 20, 1991

US-PAT-NO: 5041788
DOCUMENT-IDENTIFIER: US 5041788 A

TITLE: Simply supported ring gear for autotuneable body resonator

DATE-ISSUED: August 20, 1991

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Kontor; Kenneth C.	Chesterland	OH		
Amor; William H.	Chagrin Falls	OH		
Page; Kenneth J.	Mentor	OH		

US-CL-CURRENT: 324/318; 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 19. Document ID: US 4887039 A

L14: Entry 19 of 23   File: USPT   Dec 12, 1989

US-PAT-NO: 4887039
DOCUMENT-IDENTIFIER: US 4887039 A

TITLE: Method for providing multiple coaxial cable connections to a radio-frequency antenna without baluns

DATE-ISSUED: December 12, 1989

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Roemer; Peter B.	Schenectady	NY		
Edelstein; William A.	Schenectady	NY		
Hayes; Cecil E.	Wauwatosa	WI		
Eash; Matthew G.	Oconomowoc	WI		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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20. Document ID: US 4857850 A

L14: Entry 20 of 23   File: USPT   Aug 15, 1989

US-PAT-NO: 4857850
DOCUMENT-IDENTIFIER: US 4857850 A

TITLE: Passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus

DATE-ISSUED: August 15, 1989

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Mametsa; Henri-Jose	Montigny le Bretonneux			FRX
Jacob; Herve	Gyf sur Yvette			FRX

US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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21. Document ID: US 4694254 A

L14: Entry 21 of 23   File: USPT   Sep 15, 1987

US-PAT-NO: 4694254
DOCUMENT-IDENTIFIER: US 4694254 A

TITLE: Radio-frequency spectrometer subsystem for a magnetic resonance imaging system

DATE-ISSUED: September 15, 1987

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vatis; Dimitrios	Schenectady	NY		
Smith; Lowell S.	Schenectady	NY		

US-CL-CURRENT: 324/309; 324/313, 324/314, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 22. Document ID: US 4689563 A

L14: Entry 22 of 23   File: USPT   Aug 25, 1987

US-PAT-NO: 4689563
DOCUMENT-IDENTIFIER: US 4689563 A

TITLE: High-field nuclear magnetic resonance imaging/spectroscopy system

DATE-ISSUED: August 25, 1987

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bottomley; Paul A.	Clifton Park	NY		
Edelstein; William A.	Schenectady	NY		
Hart, Jr.; Howard R.	Schenectady	NY		
Schenck; John F.	Schenectady	NY		
Redington; Rowland W.	Schenectady	NY		
Leue; William M.	Albany	NY		

US-CL-CURRENT: 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 23. Document ID: US 4620155 A

L14: Entry 23 of 23   File: USPT   Oct 28, 1986

US-PAT-NO: 4620155
DOCUMENT-IDENTIFIER: US 4620155 A

TITLE: Nuclear magnetic resonance imaging antenna subsystem having a plurality of non-orthogonal surface coils

DATE-ISSUED: October 28, 1986

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Edelstein; William A.	Schenectady	NY		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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Term	Documents
PLURALITY.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1992882
PLURALITIES.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	13902
PLURALITYS.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	2
ANTENNA.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	180170
ANTENNAS.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	37033
(5 AND (ANTENNA WITH PLURALITY)).USPT,PGPB,JPAB,EPAB,DWPI,TDBD.	23

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☐ 1. Document ID: US 6255817 B1

L17: Entry 1 of 19 File: USPT Jul 3, 2001

US-PAT-NO: 6255817
DOCUMENT-IDENTIFIER: US 6255817 B1

TITLE: Nuclear magnetic resonance logging with azimuthal resolution

DATE-ISSUED: July 3, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Poitzsch; Martin E.	Sugar Land	TX		
Speier; Peter	Stafford	TX		
Ganesan; Krishnamurthy	Sugar Land	TX		
Chang; Shu-Kong	Sugar Land	TX		
Goswami; Jaideva C.	Houston	TX		

US-CL-CURRENT: 324/303; 324/300

Full | Title | Citation | Front | Review | Classification | Date | Reference | KWIC | Draw. Desc | Image

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☐ 2. Document ID: US 6249252 B1

L17: Entry 2 of 19 File: USPT Jun 19, 2001

US-PAT-NO: 6249252
DOCUMENT-IDENTIFIER: US 6249252 B1

TITLE: Wireless location using multiple location estimators

DATE-ISSUED: June 19, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Dupray; Dennis J.	Denver	CO		

US-CL-CURRENT: 342/450; 342/357.01, 342/457

Full | Title | Citation | Front | Review | Classification | Date | Reference | KWIC | Draw. Desc | Image

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☐ 3. Document ID: US 6246898 B1

L17: Entry 3 of 19 File: USPT Jun 12, 2001

US-PAT-NO: 6246898
DOCUMENT-IDENTIFIER: US 6246898 B1

TITLE: Method for carrying out a medical procedure using a three-dimensional tracking and imaging system

DATE-ISSUED: June 12, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vesely; Ivan	Cleveland Heights	OH		
Smith; Wayne	London			CAX
Klein; George	London			CAX
Burkhoff; Daniel	Tenafly	NJ		

US-CL-CURRENT: 600/424; 600/429, 600/439, 606/130

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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4. Document ID: US 6229310 B1

L17: Entry 4 of 19   File: USPT   May 8, 2001

US-PAT-NO: 6229310
DOCUMENT-IDENTIFIER: US 6229310 B1

TITLE: Magnetic resonance imaging excitation and reception methods and apparatus

DATE-ISSUED: May 8, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Green; Charles	Holbrook	NY		
Votruba; Jan	Ridge	NY		
Eydelman; Gregory	West Hempstead	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 324/318; 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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5. Document ID: US 6136274 A

L17: Entry 5 of 19   File: USPT   Oct 24, 2000

US-PAT-NO: 6136274
DOCUMENT-IDENTIFIER: US 6136274 A

TITLE: Matrices with memories in automated drug discovery and units therefor

DATE-ISSUED: October 24, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Nova; Michael P.	Rancho Santa Fe	CA		
Lillig; John E.	Poway	CA		
Karunaratne; Kanchana Sanjaya Gunesekera	San Diego	CA		
O'Neil; Donald	San Diego	CA		
Ewing; William	San Diego	CA		
Satoda; Yozo	San Diego	CA		

US-CL-CURRENT: 422/102; 422/101, 422/104, 435/288.4, 435/288.5, 435/297.1, 435/303.1, 435/305.2

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 6. Document ID: US 6056744 A

L17: Entry 6 of 19   File: USPT   May 2, 2000

US-PAT-NO: 6056744
DOCUMENT-IDENTIFIER: US 6056744 A

TITLE: Sphincter treatment apparatus

DATE-ISSUED: May 2, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Edwards; Stuart D.	Portola Valley	CA		

US-CL-CURRENT: 606/41; 607/101

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 7. Document ID: US 6017496 A

L17: Entry 7 of 19   File: USPT   Jan 25, 2000

US-PAT-NO: 6017496
DOCUMENT-IDENTIFIER: US 6017496 A

TITLE: Matrices with memories and uses thereof

DATE-ISSUED: January 25, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Nova; Michael P.	Santa Fe	CA		
Parandoosh; Zahra	San Diego	CA		
Senyei; Andrew E.	La Jolla	CA		
Xiao; Xiao-Yi	San Diego	CA		
David; Gary S.	La Jolla	CA		
Satoda; Yozo	San Diego	CA		
Zhao; Chanfeng	San Diego	CA		
Potash; Hanan	La Jolla	CA		

US-CL-CURRENT: 422/68.1; 422/102, 422/104, 422/107, 422/108, 422/50, 422/58, 422/99, 435/6, 435/7.1, 702/22

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

8. Document ID: US 5967986 A

L17: Entry 8 of 19   File: USPT   Oct 19, 1999

US-PAT-NO: 5967986
DOCUMENT-IDENTIFIER: US 5967986 A

TITLE: Endoluminal implant with fluid flow sensing capability

DATE-ISSUED: October 19, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Cimochowski; George E.	Dallas	PA		
Keilman; George W.	Woodinville	WA		

US-CL-CURRENT: 600/454; 600/504, 600/505

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

9. Document ID: US 5939883 A

L17: Entry 9 of 19   File: USPT   Aug 17, 1999

US-PAT-NO: 5939883
DOCUMENT-IDENTIFIER: US 5939883 A

TITLE: Magnetic resonance imaging excitation and reception methods and apparatus

DATE-ISSUED: August 17, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Green; Charles	Holbrook	NY		
Votruba; Jan	Ridge	NY		
Eydelman; Gregory	West Hempstead	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 10. Document ID: US 5530351 A

L17: Entry 10 of 19   File: USPT   Jun 25, 1996

US-PAT-NO: 5530351
DOCUMENT-IDENTIFIER: US 5530351 A

TITLE: NMR tomography apparatus with combined radio frequency antenna and gradient coil

DATE-ISSUED: June 25, 1996

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Moritz; Michael	Mistelgau			DEX
Pausch; Guenther	Effeltrich			DEX

US-CL-CURRENT: 324/309; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 11. Document ID: US 5396174 A

L17: Entry 11 of 19   File: USPT   Mar 7, 1995

US-PAT-NO: 5396174
DOCUMENT-IDENTIFIER: US 5396174 A

TITLE: Antenna arrangement with shielding for a nuclear magnetic resonance tomography apparatus

DATE-ISSUED: March 7, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hanke; Wilhelm	Rueckersdorf			DEX
Morita; Michael	Mistelgau			DEX
Freisen, deceased; Ludger	late of Erlangen			DEX

US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 12. Document ID: US 5351688 A

L17: Entry 12 of 19   File: USPT   Oct 4, 1994

US-PAT-NO: 5351688
DOCUMENT-IDENTIFIER: US 5351688 A

TITLE: NMR quadrature detection solenoidal coils

DATE-ISSUED: October 4, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Jones; Randall W.	Bellevue	NE		

US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 13. Document ID: US 5284144 A

L17: Entry 13 of 19   File: USPT   Feb 8, 1994

US-PAT-NO: 5284144
DOCUMENT-IDENTIFIER: US 5284144 A

TITLE: Apparatus for hyperthermia treatment of cancer

DATE-ISSUED: February 8, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Delannoy; Jose	Monsen Baroeul			FRX
Le Bihan; Denis	Rockville	MD		
Chen; Ching-nien	Catonsville	MD		
Levin; Ronald L.	Olney	MD		
Turner; Robert	Bethesda	MD		

US-CL-CURRENT: 600/412; 324/315, 600/422, 607/154

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 14. Document ID: US 5050605 A

L17: Entry 14 of 19   File: USPT   Sep 24, 1991

US-PAT-NO: 5050605
DOCUMENT-IDENTIFIER: US 5050605 A

TITLE: Magnetic resonance imaging antennas with spiral coils and imaging methods employing the same

DATE-ISSUED: September 24, 1991

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Eydelman; Gregory	West Hempstead	NY		
Giambalvo; Anthony	Kings Park	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 15. Document ID: US 4887039 A

L17: Entry 15 of 19   File: USPT   Dec 12, 1989

US-PAT-NO: 4887039
DOCUMENT-IDENTIFIER: US 4887039 A

TITLE: Method for providing multiple coaxial cable connections to a radio-frequency antenna without baluns

DATE-ISSUED: December 12, 1989

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Roemer; Peter B.	Schenectady	NY		
Edelstein; William A.	Schenectady	NY		
Hayes; Cecil E.	Wauwatosa	WI		
Eash; Matthew G.	Oconomowoc	WI		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 16. Document ID: US 4857850 A

L17: Entry 16 of 19   File: USPT   Aug 15, 1989

US-PAT-NO: 4857850
DOCUMENT-IDENTIFIER: US 4857850 A

TITLE: Passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus

DATE-ISSUED: August 15, 1989

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Mametsa; Henri-Jose	Montigny le Bretonneux			FRX
Jacob; Herve	Gyf sur Yvette			FRX

US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 17. Document ID: US 4694254 A

L17: Entry 17 of 19   File: USPT   Sep 15, 1987

US-PAT-NO: 4694254
DOCUMENT-IDENTIFIER: US 4694254 A

TITLE: Radio-frequency spectrometer subsystem for a magnetic resonance imaging system

DATE-ISSUED: September 15, 1987

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vatis; Dimitrios	Schenectady	NY		
Smith; Lowell S.	Schenectady	NY		

US-CL-CURRENT: 324/309; 324/313, 324/314, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 18. Document ID: US 4689563 A

L17: Entry 18 of 19   File: USPT   Aug 25, 1987

US-PAT-NO: 4689563
DOCUMENT-IDENTIFIER: US 4689563 A

TITLE: High-field nuclear magnetic resonance imaging/spectroscopy system

DATE-ISSUED: August 25, 1987

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bottomley; Paul A.	Clifton Park	NY		
Edelstein; William A.	Schenectady	NY		
Hart, Jr.; Howard R.	Schenectady	NY		
Schenck; John F.	Schenectady	NY		
Redington; Rowland W.	Schenectady	NY		
Leue; William M.	Albany	NY		

US-CL-CURRENT: 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 19. Document ID: US 4620155 A

L17: Entry 19 of 19   File: USPT   Oct 28, 1986

US-PAT-NO: 4620155
DOCUMENT-IDENTIFIER: US 4620155 A

TITLE: Nuclear magnetic resonance imaging antenna subsystem having a plurality of non-orthogonal surface coils

DATE-ISSUED: October 28, 1986

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Edelstein; William A.	Schenectady	NY		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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Term	Documents
DISPOSED.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1523532
DISPOSEDS.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	4
LOCATED.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1821661
LOCATEDS.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	3
(16 AND (LOCATED OR DISPOSED)).USPT,PGPB,JPAB,EPAB,DWPI,TDBD.	19

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L17: Entry 16 of 19 File: USPT Aug 15, 1989

DOCUMENT-IDENTIFIER: US 4857850 A
TITLE: Passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus

ABPL:
An antenna for nuclear magnetic resonance imaging devices has two electromagnetic circuits connected to each other so as to produce mutual opposition of their electromotive force when they are placed in a uniform electromagnetic induction field. It is considered that a localized transmitter does not produce a uniform field. This antenna therefore makes it possible to detect this field if it comes close to this latter. On the other hand, this antenna does not present any reactive field to a transmitter in which it may be considered that the field opposite to said antenna is uniform.

BSPR:
The present invention relates to a passive-decoupling receiving antenna for a nuclear magnetic resonance (NMR) imaging apparatus. The invention is more particularly applicable to the medical field in which NMR provides a precious aid in diagnostic techniques. Applications to other fields, however, may also be contemplated.

BSPR:
An apparatus for NMR imaging essentially includes means for subjecting a body to be examined to a constant and intense magnetic field B.sub.O. While being subjected to this influence, the body then receives a radiofrequency excitation from a transmitting antenna in order to induce resonance of oscillation of the magnetic moments of its particles. As soon as this radiofrequency excitation is discontinued, the next step consists in measuring the resonance signal emitted by the body as feedback when the magnetic moments of the particles tend to realign with the field B.sub.O. In order to receive the emitted signal, it is sometimes the practice to employ so-called surface antennas which are placed on the body. The advantage of surface antennas with respect to transmitting antennas forming part of the apparatus essentially lies in the fact that they can be placed in immediate proximity to the emitting particles whereas transmitting antennas are located at a distinctly greater distance. The use of these surface antennas permits a substantially enhanced signal-to-noise ratio of the detected signal.

BSPR:
Surface antennas is most common use (rachis, orbit, breast, knee) are usually spatially decoupled from the transmitting antenna. Said transmitting antenna is usually horizontally polarized so as to minimize eddy-current losses in a patient who is lying in a recumbent position within the apparatus. In the case of surface receiving antennas, these antennas are placed so as to have a vertical polarization of the magnetic field with a view to preventing coupling with the transmitting antenna during transmission. In fact, a strong coupling between the two antennas is highly undesirable since the reactive field induced by the receiving antenna tends to oppose that of the transmitting antenna which serves to excite the protons. At the receiving end, the problem is less crucial since the surface antenna is much closer to the useful signal source.

BSPR:
The spatial decoupling thus proposed is attended by disadvantages in some instances. For example, vertical polarization of the surface antenna may make it necessary for the patient to turn on one side during an examination in which this antenna is applied against his or her ear. Similarly, the patient

may also be required turn over on the couch and lie the other side if it is desired to place the receiving antenna against his or her other ear.

BSPR:
The aim of the present invention is to overcome these disadvantages by proposing a receiving antenna which is provided with means for decoupling the two antennas during transmission while at the same time ensuring symmetrization of the antenna for receiving the resonance signal as well as converting its impedance for transmission of said signal. In other words, even when placed in a position parallel to a transmitting antenna which is a body antenna, said receiving antenna is insensitive to the uniform field of this latter. This result is obtained without degradation of the signal on reception. This receiving antenna therefore permits observation of any region of the body such as the ear, for instance. In addition, the patient is no longer required to lie on one side.

BSPR:
The invention accordingly relates to a passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus, as distinguished by the fact that said antenna has two adjacent and opposing magnetic circuits for mutually opposing their induced electromotive force when these induced electromotive forces are induced by a transmitter which emits a substantially uniform field opposite to said antenna, the first circuit being constituted by one or a plurality of magnetic loops, the second circuit being constituted by a plurality of magnetic loops having a total area which is substantially equal to the area of the loops of the first circuit, and that the plane of the loops of the second circuit is displaced with respect to the plane of the loops of the first circuit.

DRPR:
FIG. 1 illustrates an NMR imaging apparatus equipped with an antenna in accordance with the invention.

DRPR:
FIGS. 2a and 2b are respectively a schematic diagram and an operating diagram of said antenna.

DRPR:
FIGS. 3a and 3b illustrate one example of construction of an antenna in accordance with the general principle of the invention.

DRPR:
FIG. 4 is an operating diagram of the antennas of the preceding example.

DEPR:
FIG. 1 shows an NMR imaging apparatus provided with an element 1 for producing an intense magnetic field B.sub.O. A table 2 supports a body 3 which is subjected to the influence of said field. A generating unit 4 produces radiofrequency excitation of a transmitting antenna 5. By way of example, this transmitting antenna has four radiating conductors such as the conductor 6. At the receiver, the signal is collected by a surface antenna 7 which is endowed with the improvement in accordance with the invention. This surface antenna is symmetrized and matched. The signal detected by the antenna is directed via a high-frequency line 8 to receiving and processing circuits 9 which are in turn connected to visual display means 10 for observing cross-sectional images of regions examined within the body 3. A sequencer 11 controls the generating unit 4 as well as the receiving and processing unit 9.

DEPR:
FIGS. 2a and 2b illustrate the general principle of an antenna in accordance with the invention. The opposing action of the electromotive forces induced in the two circuits appears in the form of counterrotating currents induced within each of these circuits when they are subjected to one and the same field. Two loops 12, 13 having the same area and placed on supports 14, 15 are in fact connected to each other in series so that, in a uniform field, the currents induced within the loops act in opposition and cancel each other (hence the term "counterrotating"). However, just as the influences exerted by a transmitter located at a distance from the antenna in accordance with the invention have no effect on this latter insofar as these influences on both

portions of the anten[illegible] are of the same magnitude, so t[illegible] influences exerted by a transmitter located in proximity to the antenna may be differentiated. FIG. 2b shows the progressive variation of the reactive field set up in opposition to an external induction by each loop as a function of an abscissa measured on an axis x perpendicular to the plane of the loops. At a substantial distance from these loops or in other words a distance corresponding to at least once their diameter, these fields which are fictitiously opposed (on account of the reverse electrical connection) accordingly have the effect of canceling each other. In proximity to the antenna, one of the two fields is predominant according to the side considered. In consequence, an emitter (the protons which are excited within the body and return to their state of equilibrium after excitation) which is placed at this location in close proximity to the antenna has a greater influence on one of the loops than on the other. One of the two induced currents is preponderant over the other, with the result that a signal can therefore be detected. The dashed-line curve virtually indicates the sensitivity of the antenna thus provided. A number of different forms of circuit based on this principle may be contemplated.

DEPR:
In NMR imagery, the maximum useful signal must be detected on reception. It is apparent from FIG. 2, however, that if the patient is placed next to the loop 12, the induced current I.sub.2 within the loop 13 opposes the current I.sub.1 of the main loop 12. In order to minimize this effect, it would be possible to increase the distance d between the two loops. However, the basic assumption in regard to uniformity of field of the transmitting antenna makes it necessary on the contrary to place the loops at a short distance from each other. In order to arrive at a compromise in regard to this problem, the secondary loop is preferably constituted by n small loops having a total area which is equal to that of the large loop. In this manner, the induced reactive fields are compensated when they originate from a distant (uniform) transmitter as is the case with the transmitting antenna. Preferably, the axes of these secondary loops are located in uniformly spaced relation to each other and to the main axis in order to place these loops at a distance from the main circuit. FIGS. 3a and 3b and then FIG. 5 present two examples of construction in which the secondary circuit is constituted by four small loops.

DEPR:
In FIG. 3a, the set of small loops 16 of the secondary circuit and the main loop 17 are placed on supports 18, 19 spaced at a distance d. The small loops 16 and the main loop 17 are in series and are preferably circular in all cases. The area of each small loop is substantially equal to one-quarter of the area of the large loop. Capacitors 19, 20 serve to induce resonance respectively in the large loop and in the secondary loops. The position of the capacitors within the loops makes it possible to have a zero mean voltage at the terminals of the large loop (and ipso facto of all the secondary loops). FIG. 3b shows that the axes of the small loops are located at a distance from the center of the main loop which is preferably equal to the radius r of this latter. A screened conductor 21 is connected to a hot point 22 of the main loop. The hot point 22 is located half-way along the main loop 17. The screen 23 of the conductor 21 also serves as a screen for the loop 17. Said screened conductor makes it possible to symmetrize the antenna and to return the signal to an amplifier having a high input impedance which also has the function of impedance conversion. Symmetrization results from connection of the core 21 of the screened conductor to the loop 17 at the hot point 22 of the capacitor 19. The amplifier is driven by the voltage between the conductor 21 and the cold point 23.

DEPR:
FIG. 4 shows the operating diagram of the antennas of FIGS. 3 and 5. Whereas it may be considered that the induced reactive fields oppose each other exactly in the case of a transmitter located at a substantial distance from the antenna, compensation does not take place at a short distance. Moreover, by reason of the dissymmetry of construction of the two magnetic circuits, one of these circuits, namely the main circuit, has a much broader range of influence than the other. In consequence, the sensitivity of the antenna is not impaired to any excessive degree in its sensitive detection zone (portion a).

DEPR:
FIG. 5 presents another example of construction of an antenna which operates on the principle described earlier. In this embodiment, the two circuits are in series. The currents within the small loops are in opposition to the main current when the assembly is placed in a uniform field. In the same manner as in FIG. 3a, the small loops 16 of the secondary circuit are uniformly distributed about the axis of the loop of the main circuit. Construction of this embodiment, as of the other embodiments, on a single double-face printed circuit is possible. The connections 24 and 25 shown in full lines represent portions of circuit on a first face. The dashed-line connections 26 and 27 illustrate the portions on another face. Interconnection between the two faces is made by means of metallized holes, for example. Three capacitors 26 to 28 having the same value cause the entire circuit to resonate. The same technique as that described earlier permits symmetrization of the circuit and impedance matching.

DEPR:
The circuit 29 of FIG. 6 has the function of converting the impedance of the antenna so as to match it with that of the line 8. This circuit is placed in immediate proximity to the antenna, for example on the same support as this latter. Said circuit includes a field-effect transistor 31 supplied by a biasing circuit 32 decoupled from the high frequency. A variable capacitor 33 mounted in parallel between ground and the core 21 which is connected to the gate of transistor 31 serves to vary the resonance frequency of the antenna over a predetermined range. A bias resistor 34 and a decoupling capacitor 35 are mounted on the source of the transistor 31. The amplified signal is collected from the drain of the transistor 31 and transmitted to the processing unit 9 via the connection 8.

CLPR:
1. A passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus, wherein said antenna has two adjacent and opposing magnetic circuits for mutually opposing their induced electromotive force when these electromotive forces are induced by a transmitter which emits a substantial uniform field opposed to said antenna the first circuit being constituted by at least one magnetic loop, the second circuit being constituted by a plurality of magnetic loops having a total area which is substantially equal to area of said at least one loop of the first circuit, and wherein the plane of the loops of the second circuit is displaced with respect to the plane of said at least one loop of the first circuit, wherein each of said circuits is flat, said antenna further including a single flat support with said first circuit being mounted on one face of said support and said second circuit being mounted on a second face of said support wherein said first and second circuits are flat and are lying flat respectively on each of said faces of said single flat support.

CLPR:
2. An antenna according to claim 1, wherein the loops of the second circuit are in series with each other and with the loop or loops of the first circuit.

CLPR:
3. An antenna according to claim 1, wherein the loops are substantially circular.

CLPR:
4. An antenna according to claim 1 wherein said flat support is a double-face printed circuit board.

CLPR:
5. A passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus, wherein said antenna has two adjacent and opposing magnetic circuits for mutually opposing their induced electromotive force when these induced electromotive forces are induced by a transmitter which emits a substantial uniform field opposite to said antenna, the first circuit being constituted by one magnetic loop, the second circuit being constituted by a plurality of magnetic loops having a total area which is substantially equal to area of said one loop of the first circuit, and

wherein the plane of the loops of the second circuit is displaced with respect to the plane of said one loop of the first circuit, and where axes perpendicular at the centers thereof to the loops of the second circuit are located at uniform intervals in space about an axis perpendicular to the loop of the first circuit.

CLPR:
6. An antenna according to claim 5, wherein said two circuits are mounted on the faces of a single flat support.

CLPR:
7. An antenna according to claim 5, wherein said first circuit has a high-frequency line section in which a ground conductor forms part of the loop of said circuit and in which a core which serve to conduct the induced electromotive-force signal is connected on the one hand to a receiving circuit and on the other hand to the remainder of said first circuit.

CLPR:
8. An antenna according to claim 7, wherein the receiving circuit has a high input-impedance circuit which is connected to said first circuit.

CLPR:
9. An antenna according to claim 5, wherein said two circuits are resonant and frequency-tuned to a resonance frequency of the apparatus by means of capacitors distributed within the circuits in such a manner as to ensure that a zero mean voltage appears at the terminals of said circuits.

CLPR:
10. An antenna according to claim 6, wherein said flat support is a double-face printed circuit board.

CLPR:
11. A passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus, wherein said antenna has two adjacent and opposing magnetic circuits for mutually opposing their induced electromotive force when these induced electromotive forces are induced by a transmitter which emits a substantial uniform field opposite to said antenna, the first circuit being constituted by at least one magnetic loop, the second circuit being constituted by a plurality of magnetic loops having a total area which is substantially equal to the area of said at least one loop of the first circuit, and wherein the plane of the loops of the second circuit is displaced with respect to the plane of said at least one loop of the first circuit, wherein the first circuit has a high-frequency line section in which a ground conductor forms part of said at least one loop of said circuit and in which a core which serve to conduct the induced electromotive-force signal is connected on the one hand to a receiving circuit and on the other hand to the remainder of said first circuit.

CLPR:
12. An antenna according to claim 11, wherein the receiving circuit has a high input-impedance circuit which is connected to the first circuit.

CLPR:
13. A passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus, wherein said antenna has two adjacent and opposing magnetic circuits for mutually opposing their induced electromotive force when these induced electromotive forces are induced by a transmitter which emits a substantial uniform field opposite to said antenna, the first circuit being constituted by at least one magnetic loop, the second circuit being constituted by a plurality of magnetic loops having a total area which is substantially equal to the area of said at least one loop of the first circuit, and wherein the plane of the loops of the second circuit is displaced with respect to the plane of said at least one loop of the first circuit, wherein said two circuits are resonant and frequency-tuned to a resonance frequency of the apparatus by means of capacitors distributed within the circuits in such a manner as to ensure a zero mean voltage appears at the terminals of said circuits.

WEST

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Search Results - Record(s) 1 through 18 of 18 returned.

☐ 1. Document ID: US 6255817 B1

L18: Entry 1 of 18 File: USPT Jul 3, 2001

US-PAT-NO: 6255817
DOCUMENT-IDENTIFIER: US 6255817 B1

TITLE: Nuclear magnetic resonance logging with azimuthal resolution

DATE-ISSUED: July 3, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Poitzsch; Martin E.	Sugar Land	TX		
Speier; Peter	Stafford	TX		
Ganesan; Krishnamurthy	Sugar Land	TX		
Chang; Shu-Kong	Sugar Land	TX		
Goswami; Jaideva C.	Houston	TX		

US-CL-CURRENT: 324/303; 324/300

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

☐ 2. Document ID: US 6249252 B1

L18: Entry 2 of 18 File: USPT Jun 19, 2001

US-PAT-NO: 6249252
DOCUMENT-IDENTIFIER: US 6249252 B1

TITLE: Wireless location using multiple location estimators

DATE-ISSUED: June 19, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Dupray; Dennis J.	Denver	CO		

US-CL-CURRENT: 342/450; 342/357.01, 342/457

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

☐ 3. Document ID: US 6246898 B1

L18: Entry 3 of 18 File: USPT Jun 12, 2001

US-PAT-NO: 6246898
DOCUMENT-IDENTIFIER: US 6246898 B1

TITLE: Method for carrying out a medical procedure using a three-dimensional tracking and imaging system

DATE-ISSUED: June 12, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vesely; Ivan	Cleveland Heights	OH		
Smith; Wayne	London			CAX
Klein; George	London			CAX
Burkhoff; Daniel	Tenafly	NJ		

US-CL-CURRENT: 600/424; 600/429, 600/439, 606/130

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 4. Document ID: US 6229310 B1

L18: Entry 4 of 18   File: USPT   May 8, 2001

US-PAT-NO: 6229310
DOCUMENT-IDENTIFIER: US 6229310 B1

TITLE: Magnetic resonance imaging excitation and reception methods and apparatus

DATE-ISSUED: May 8, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Green; Charles	Holbrook	NY		
Votruba; Jan	Ridge	NY		
Eydelman; Gregory	West Hempstead	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 324/318; 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 5. Document ID: US 6136274 A

L18: Entry 5 of 18   File: USPT   Oct 24, 2000

US-PAT-NO: 6136274
DOCUMENT-IDENTIFIER: US 6136274 A

TITLE: Matrices with memories in automated drug discovery and units therefor

DATE-ISSUED: October 24, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Nova; Michael P.	Rancho Santa Fe	CA		
Lillig; John E.	Poway	CA		
Karunaratne; Kanchana Sanjaya Gunesekera	San Diego	CA		
O'Neil; Donald	San Diego	CA		
Ewing; William	San Diego	CA		
Satoda; Yozo	San Diego	CA		

US-CL-CURRENT: 422/102; 422/101, 422/104, 435/288.4, 435/288.5, 435/297.1, 435/303.1, 435/305.2

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 6. Document ID: US 6056744 A

L18: Entry 6 of 18   File: USPT   May 2, 2000

US-PAT-NO: 6056744
DOCUMENT-IDENTIFIER: US 6056744 A

TITLE: Sphincter treatment apparatus

DATE-ISSUED: May 2, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Edwards; Stuart D.	Portola Valley	CA		

US-CL-CURRENT: 606/41; 607/101

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 7. Document ID: US 5967986 A

L18: Entry 7 of 18   File: USPT   Oct 19, 1999

US-PAT-NO: 5967986
DOCUMENT-IDENTIFIER: US 5967986 A

TITLE: Endoluminal implant with fluid flow sensing capability

DATE-ISSUED: October 19, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Cimochowski; George E.	Dallas	PA		
Keilman; George W.	Woodinville	WA		

US-CL-CURRENT: 600/454; 600/504, 600/505

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 8. Document ID: US 5939883 A

L18: Entry 8 of 18   File: USPT   Aug 17, 1999

US-PAT-NO: 5939883
DOCUMENT-IDENTIFIER: US 5939883 A

TITLE: Magnetic resonance imaging excitation and reception methods and apparatus

DATE-ISSUED: August 17, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Green; Charles	Holbrook	NY		
Votruba; Jan	Ridge	NY		
Eydelman; Gregory	West Hempstead	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 9. Document ID: US 5530351 A

L18: Entry 9 of 18   File: USPT   Jun 25, 1996

US-PAT-NO: 5530351
DOCUMENT-IDENTIFIER: US 5530351 A

TITLE: NMR tomography apparatus with combined radio frequency antenna and gradient coil

DATE-ISSUED: June 25, 1996

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Moritz; Michael	Mistelgau			DEX
Pausch; Guenther	Effeltrich			DEX

US-CL-CURRENT: 324/309; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

10. Document ID: US 5396174 A

L18: Entry 10 of 18   File: USPT   Mar 7, 1995

US-PAT-NO: 5396174
DOCUMENT-IDENTIFIER: US 5396174 A

TITLE: Antenna arrangement with shielding for a nuclear magnetic resonance tomography apparatus

DATE-ISSUED: March 7, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hanke; Wilhelm	Rueckersdorf			DEX
Morita; Michael	Mistelgau			DEX
Freisen, deceased; Ludger	late of Erlangen			DEX

US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

11. Document ID: US 5351688 A

L18: Entry 11 of 18   File: USPT   Oct 4, 1994

US-PAT-NO: 5351688
DOCUMENT-IDENTIFIER: US 5351688 A

TITLE: NMR quadrature detection solenoidal coils

DATE-ISSUED: October 4, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Jones; Randall W.	Bellevue	NE		

US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

12. Document ID: US 5284144 A

L18: Entry 12 of 18   File: USPT   Feb 8, 1994

US-PAT-NO: 5284144
DOCUMENT-IDENTIFIER: US 5284144 A

TITLE: Apparatus for hyperthermia treatment of cancer

DATE-ISSUED: February 8, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Delannoy; Jose	Monsen Baroeul			FRX
Le Bihan; Denis	Rockville	MD		
Chen; Ching-nien	Catonsville	MD		
Levin; Ronald L.	Olney	MD		
Turner; Robert	Bethesda	MD		

US-CL-CURRENT: 600/412; 324/315, 600/422, 607/154

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

13. Document ID: US 5050605 A

L18: Entry 13 of 18   File: USPT   Sep 24, 1991

US-PAT-NO: 5050605
DOCUMENT-IDENTIFIER: US 5050605 A

TITLE: Magnetic resonance imaging antennas with spiral coils and imaging methods employing the same

DATE-ISSUED: September 24, 1991

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Eydelman; Gregory	West Hempstead	NY		
Giambalvo; Anthony	Kings Park	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

14. Document ID: US 4887039 A

L18: Entry 14 of 18   File: USPT   Dec 12, 1989

US-PAT-NO: 4887039
DOCUMENT-IDENTIFIER: US 4887039 A

TITLE: Method for providing multiple coaxial cable connections to a radio-frequency antenna without baluns

DATE-ISSUED: December 12, 1989

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Roemer; Peter B.	Schenectady	NY		
Edelstein; William A.	Schenectady	NY		
Hayes; Cecil E.	Wauwatosa	WI		
Eash; Matthew G.	Oconomowoc	WI		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

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15. Document ID: US 4857850 A

L18: Entry 15 of 18   File: USPT   Aug 15, 1989

US-PAT-NO: 4857850
DOCUMENT-IDENTIFIER: US 4857850 A

TITLE: Passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus

DATE-ISSUED: August 15, 1989

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Mametsa; Henri-Jose	Montigny le Bretonneux			FRX
Jacob; Herve	Gyf sur Yvette			FRX

US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

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16. Document ID: US 4694254 A

L18: Entry 16 of 18   File: USPT   Sep 15, 1987

US-PAT-NO: 4694254
DOCUMENT-IDENTIFIER: US 4694254 A

TITLE: Radio-frequency spectrometer subsystem for a magnetic resonance imaging system

DATE-ISSUED: September 15, 1987

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vatis; Dimitrios	Schenectady	NY		
Smith; Lowell S.	Schenectady	NY		

US-CL-CURRENT: 324/309; 324/313, 324/314, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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17. Document ID: US 4689563 A

L18: Entry 17 of 18   File: USPT   Aug 25, 1987

US-PAT-NO: 4689563
DOCUMENT-IDENTIFIER: US 4689563 A

TITLE: High-field nuclear magnetic resonance imaging/spectroscopy system

DATE-ISSUED: August 25, 1987

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bottomley; Paul A.	Clifton Park	NY		
Edelstein; William A.	Schenectady	NY		
Hart, Jr.; Howard R.	Schenectady	NY		
Schenck; John F.	Schenectady	NY		
Redington; Rowland W.	Schenectady	NY		
Leue; William M.	Albany	NY		

US-CL-CURRENT: 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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18. Document ID: US 4620155 A

L18: Entry 18 of 18   File: USPT   Oct 28, 1986

US-PAT-NO: 4620155
DOCUMENT-IDENTIFIER: US 4620155 A

TITLE: Nuclear magnetic resonance imaging antenna subsystem having a plurality of non-orthogonal surface coils

DATE-ISSUED: October 28, 1986

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Edelstein; William A.	Schenectady	NY		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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Term	Documents
(17 NOT 9).USPT,PGPB,JPAB,EPAB,DWPI,TDBD.	18

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Display Format: CIT Change Format

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Search Results - Record(s) 1 through 15 of 15 returned.

☐ 1. Document ID: US 6255817 B1

L19: Entry 1 of 15 File: USPT Jul 3, 2001

US-PAT-NO: 6255817
DOCUMENT-IDENTIFIER: US 6255817 B1

TITLE: Nuclear magnetic resonance logging with azimuthal resolution

DATE-ISSUED: July 3, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Poitzsch; Martin E.	Sugar Land	TX		
Speier; Peter	Stafford	TX		
Ganesan; Krishnamurthy	Sugar Land	TX		
Chang; Shu-Kong	Sugar Land	TX		
Goswami; Jaideva C.	Houston	TX		

US-CL-CURRENT: 324/303; 324/300

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 2. Document ID: US 6249252 B1

L19: Entry 2 of 15 File: USPT Jun 19, 2001

US-PAT-NO: 6249252
DOCUMENT-IDENTIFIER: US 6249252 B1

TITLE: Wireless location using multiple location estimators

DATE-ISSUED: June 19, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Dupray; Dennis J.	Denver	CO		

US-CL-CURRENT: 342/450; 342/357.01, 342/457

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 3. Document ID: US 6246898 B1

L19: Entry 3 of 15 File: USPT Jun 12, 2001

US-PAT-NO: 6246898
DOCUMENT-IDENTIFIER: US 6246898 B1

TITLE: Method for carrying out a medical procedure using a three-dimensional tracking and imaging system

DATE-ISSUED: June 12, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vesely; Ivan	Cleveland Heights	OH		
Smith; Wayne	London			CAX
Klein; George	London			CAX
Burkhoff; Daniel	Tenafly	NJ		

US-CL-CURRENT: 600/424; 600/429, 600/439, 606/130

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 4. Document ID: US 6229310 B1

L19: Entry 4 of 15   File: USPT   May 8, 2001

US-PAT-NO: 6229310
DOCUMENT-IDENTIFIER: US 6229310 B1

TITLE: Magnetic resonance imaging excitation and reception methods and apparatus

DATE-ISSUED: May 8, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Green; Charles	Holbrook	NY		
Votruba; Jan	Ridge	NY		
Eydelman; Gregory	West Hempstead	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 324/318; 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 5. Document ID: US 5967986 A

L19: Entry 5 of 15   File: USPT   Oct 19, 1999

US-PAT-NO: 5967986
DOCUMENT-IDENTIFIER: US 5967986 A

TITLE: Endoluminal implant with fluid flow sensing capability

DATE-ISSUED: October 19, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Cimochowski; George E.	Dallas	PA		
Keilman; George W.	Woodinville	WA		

US-CL-CURRENT: 600/454; 600/504, 600/505

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

6. Document ID: US 5939883 A

L19: Entry 6 of 15   File: USPT   Aug 17, 1999

US-PAT-NO: 5939883
DOCUMENT-IDENTIFIER: US 5939883 A

TITLE: Magnetic resonance imaging excitation and reception methods and apparatus

DATE-ISSUED: August 17, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Green; Charles	Holbrook	NY		
Votruba; Jan	Ridge	NY		
Eydelman; Gregory	West Hempstead	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

7. Document ID: US 5396174 A

L19: Entry 7 of 15   File: USPT   Mar 7, 1995

US-PAT-NO: 5396174
DOCUMENT-IDENTIFIER: US 5396174 A

TITLE: Antenna arrangement with shielding for a nuclear magnetic resonance tomography apparatus

DATE-ISSUED: March 7, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hanke; Wilhelm	Rueckersdorf			DEX
Morita; Michael	Mistelgau			DEX
Freisen, deceased; Ludger	late of Erlangen			DEX

US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 8. Document ID: US 5351688 A

L19: Entry 8 of 15   File: USPT   Oct 4, 1994

US-PAT-NO: 5351688
DOCUMENT-IDENTIFIER: US 5351688 A

TITLE: NMR quadrature detection solenoidal coils

DATE-ISSUED: October 4, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Jones; Randall W.	Bellevue	NE		

US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 9. Document ID: US 5284144 A

L19: Entry 9 of 15   File: USPT   Feb 8, 1994

US-PAT-NO: 5284144
DOCUMENT-IDENTIFIER: US 5284144 A

TITLE: Apparatus for hyperthermia treatment of cancer

DATE-ISSUED: February 8, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Delannoy; Jose	Monsen Baroeul			FRX
Le Bihan; Denis	Rockville	MD		
Chen; Ching-nien	Catonsville	MD		
Levin; Ronald L.	Olney	MD		
Turner; Robert	Bethesda	MD		

US-CL-CURRENT: 600/412; 324/315, 600/422, 607/154

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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10. Document ID: US 5050605 A

L19: Entry 10 of 15   File: USPT   Sep 24, 1991

US-PAT-NO: 5050605
DOCUMENT-IDENTIFIER: US 5050605 A

TITLE: Magnetic resonance imaging antennas with spiral coils and imaging methods employing the same

DATE-ISSUED: September 24, 1991

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Eydelman; Gregory	West Hempstead	NY		
Giambalvo; Anthony	Kings Park	NY		
Damadian; Raymond V.	Woodbury	NY		

US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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11. Document ID: US 4887039 A

L19: Entry 11 of 15   File: USPT   Dec 12, 1989

US-PAT-NO: 4887039
DOCUMENT-IDENTIFIER: US 4887039 A

TITLE: Method for providing multiple coaxial cable connections to a radio-frequency antenna without baluns

DATE-ISSUED: December 12, 1989

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Roemer; Peter B.	Schenectady	NY		
Edelstein; William A.	Schenectady	NY		
Hayes; Cecil E.	Wauwatosa	WI		
Eash; Matthew G.	Oconomowoc	WI		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 12. Document ID: US 4857850 A

L19: Entry 12 of 15   File: USPT   Aug 15, 1989

US-PAT-NO: 4857850
DOCUMENT-IDENTIFIER: US 4857850 A

TITLE: Passive-decoupling receiving antenna, in particular for a nuclear magnetic resonance imaging apparatus

DATE-ISSUED: August 15, 1989

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Mametsa; Henri-Jose	Montigny le Bretonneux			FRX
Jacob; Herve	Gyf sur Yvette			FRX

US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 13. Document ID: US 4694254 A

L19: Entry 13 of 15   File: USPT   Sep 15, 1987

US-PAT-NO: 4694254
DOCUMENT-IDENTIFIER: US 4694254 A

TITLE: Radio-frequency spectrometer subsystem for a magnetic resonance imaging system

DATE-ISSUED: September 15, 1987

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vatis; Dimitrios	Schenectady	NY		
Smith; Lowell S.	Schenectady	NY		

US-CL-CURRENT: 324/309; 324/313, 324/314, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Drawu Desc | Image

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☐ 14. Document ID: US 4689563 A

L19: Entry 14 of 15   File: USPT   Aug 25, 1987

US-PAT-NO: 4689563
DOCUMENT-IDENTIFIER: US 4689563 A

TITLE: High-field nuclear magnetic resonance imaging/spectroscopy system

DATE-ISSUED: August 25, 1987

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bottomley; Paul A.	Clifton Park	NY		
Edelstein; William A.	Schenectady	NY		
Hart, Jr.; Howard R.	Schenectady	NY		
Schenck; John F.	Schenectady	NY		
Redington; Rowland W.	Schenectady	NY		
Leue; William M.	Albany	NY		

US-CL-CURRENT: 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Drawu Desc | Image

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☐ 15. Document ID: US 4620155 A

L19: Entry 15 of 15   File: USPT   Oct 28, 1986

US-PAT-NO: 4620155
DOCUMENT-IDENTIFIER: US 4620155 A

TITLE: Nuclear magnetic resonance imaging antenna subsystem having a plurality of non-orthogonal surface coils

DATE-ISSUED: October 28, 1986

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Edelstein; William A.	Schenectady	NY		

US-CL-CURRENT: 324/322; 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference | KWIC | Draw Desc | Image

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Term	Documents
PLANE.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	1097563
PLANES.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	198500
(18 AND PLANE).USPT,PGPB,JPAB,EPAB,DWPI,TDBD.	15

Display 50 Documents, starting with Document: 15

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L19: Entry 15 of 15 File: USPT Oct 28, 1986

DOCUMENT-IDENTIFIER: US 4620155 A
TITLE: Nuclear magnetic resonance imaging antenna subsystem having a plurality of non-orthogonal surface coils

ABPL:
An NMR antenna subsystem has a plurality of co-planar surface coils, each comprised of a plurality of segments and elements for tuning the coil to resonance at the Larmor frequency of a nuclei specie to be investigated. Each coil has circuitry for selectively detuning that surface coil when at least one other one of the plurality of surface coils is in use. One of a pair of co-planar surface coils can be utilized for signal reception and includes a parallel-resonant detuning circuit which operates only when a relatively large magnitude RF signal is induced by an excitation signal in a second surface coil. The second surface coil includes a circuit for detuning that coil except when an externally-provided signal is present; this signal may be the RF excitation signal itself or another signal provided simultaneously with the RF excitation signal.

BSPR:
The present application relates to surface coil antennae for nuclear magnetic resonance imaging and, more particularly, to a novel nuclear magnetic resonance imaging antenna subsystem having a plurality of surface coils disposed in non-orthogonal relationship, and preferably in the same plane.

BSPR:
It is known to use a surface coil as a receiving antenna in an in vivo nuclear magnetic resonance (NMR) experiment; a surface coil is generally more sensitive to smaller volumes than the considerably larger volume coils typically utilized with head and/or body imaging NMR equipment. In the typical NMR experiment, the sample to be analyzed is immersed in a substantially homogeneous static magnetic field B.sub.0, typically directed along one axis, e.g. the Z axis, of a three-dimensional Cartesian set of coordinates. Under the influence of the magnetic field B.sub.0, the nuclei (and therefore the net magnetization M) of atoms having an odd-number of nucleons precess or rotate about the axis of the field. The rate, or frequency, at which the nuclei precese is dependent upon the strength of the applied magnetic field and on the nuclear characteristics. The angular frequency of precession .omega. is defined as the Larmor frequency and is given by the equation: .omega.=.gamma.B.sub.0, in which .gamma. is the gyromagnetic ratio (constant for each type of nucleus). The frequency at which the nuclei precess is therefore substantially dependent on the strength of the magnetic field B.sub.0, and increases with increasing field strength. Because the precessing nucleus is capable of absorbing and re-radiating electromagnetic energy, a radio-frequency (RF) magnetic field at the Larmor frequency can be utilized to excite the nuclei and receive imaging response signals therefrom. It is possible, by superimposing one or more magnetic field gradients of sufficient strength, to spread out the NMR signal spectrum of the sample and thereby distinguish NMR signals arising from different spatial positions in the sample, based on their respective resonant frequencies. Spatial positions of the NMR signals are determinable by Fourier analysis and knowledge of the configuration of the applied magnetic field gradient, while chemical-shift information can be obtained to provide spectroscopic images of the distribution of a particular specie of nucleus within the imaged sample.

BSPR:

For NMR imaging at relatively high static field B.sub.0 magnitudes (typically in excess of 0.5 Tesla (T)), having associated Larmor frequencies greater than about 10 MHz., surface coils utilized as imaging or spectroscopy receiving antennae can be constructed with relatively high quality factor Q, such that most of the resistive loss in the receiving circuit originates in the in vivo tissue sample. This is particularly important as the sensitivity of the NMR experiment requires that the receiving antenna favor the NMR response signal from a particular small excited volume of the sample, while being relatively insensitive to noise currents flowing through the total capture volume of the receiving coil.

BSPR:
It is also known that the radio-frequency (RF) fields generated by a simple loop or spiral surface coil are highly non-uniform. The surface coil reception sensitivity, which is essentially the inverse of the excitation field generated during sample irradiation, is likewise non-uniform. Hence, a relatively large RF antenna is required for transmission excitation of the sample to produce a more uniform irradiating RF field. A relatively small, but sensitive, surface receiving coil is utilized with the larger-diameter exciting surface coil.

BSPR:
Hitherto, the requirements for a relatively small-diameter receiving surface coil and a relatively large-diameter exciting surface coil has typically required that the NMR system antennae apparatus 10 (see FIG. 1) position the larger-radius R excitation antenna 11 in a first plane, e.g. in the Y-Z plane (for a three-dimensional Cartesian coordinate system having the NMR static imaging field B.sub.0 directed in the Z direction), and position the receiving antenna 12, having a diameter r no greater than one-half the exciting antenna radius R, in a second plane, e.g. the X-Z plane, essentially orthogonal to the exciting transmitter first plane, e.g. the Y-Z plane. The essentially orthogonal placement of the exciting and receiving coils 11 and 12 is based upon several phenomena: the need to prevent currents (induced in the receiving coil during the presence of an irradiating RF magnetic field B.sub.x, e.g. in the X direction, for the illustrated transmitting coil in the Y-Z plane) from damaging the sensitive reception preamplifier, typically connected to receive coil terminals 12a and 12b to receive the induced reception signal voltage V.sub.r thereat; the need to prevent the currents induced in surface coil 12 from, in turn, producing an RF magnetic field B.sub.y which would have a component in the X direction if the receive coil 12 were not situated exactly in the X-Z plane and which would cancel out a portion of the excitation magnetic field B.sub.x ; and the need to avoid the electrical coupling of transmitting coil 11 to receiving coil 12 after the excitation of the sample. The currents induced in reception coil 12 can be prevented from damaging the receive coil preamplifier by utilizing resonant circuitry, as at terminals 12a and 12b, to isolate the subsequent preamplifier (not shown) during periods when a large magnitude of an excitation voltage V.sub.t is present at the terminals 11a and 11b of the transmitting antenna. However, the production of an induced RF magnetic field has hitherto only been reduced by the aforementioned essentially orthogonal placement of the two surface coils 11 and 12, and the art has not otherwise considered the problem of surface coil-to-surface coil coupling in the receive mode, which coupling causes criticality in the tuning adjustments of receiving coil 12 due to the relative orientation of coils 11 and 12 and can induce additional noise in the receiving antenna 12 caused by noise currents in the transmitting coil 11.

BSPR:
It is especially desirable, to facilitate placement of the antennae during in vivo imaging of a portion of the human anatomy, to have both the transmission excitation surface coil antenna 11 and the response signal receiving antenna 12 in a substantially planar configuration as, for example, described and claimed in application Ser. No. 641,540, filed on even date herewith, assigned to the assignee of the present application and incorporated herein in its entirety by reference. A highly desirable NMR imaging antenna has at least two surface coils, at least one of which is utilized for excitation signal transmission and at least one other one of which is utilized for response signal reception, but which are so decoupled as to be devoid of induced counter fields during excitation irradiation and to be devoid of damping and other deleterious effects during image signal reception.

BSPR:
In accordance with the invention, an NMR antenna subsystem has a plurality of co-planar and substantially concentric surface coils, each comprised of a plurality of segments having means interposed between segments for tuning, in conjunction with distributed capacitances, the surface coil to resonance at the Larmor frequency of a nuclei specie to be investigated. Each coil has means, interposed between adjacent ends of a pair of consecutive segments, for selectively detuning that surface coil when at least one other one of the plurality of surface coils is in use; the detuned coil has substantially no effect upon the at least one other co-planar coil.

BSPR:
In a presently preferred embodiment, the subsystem comprises a pair of co-planar surface coils. A first surface coil, of smaller effective radius, is utilized for signal reception and includes a parallel-resonant detuning circuit which operates only when either a switching signal is applied or a relatively large magnitude RF signal is induced in the first surface coil by an excitation signal in a second surface coil, having a larger effective radius than, and surrounding, the first surface coil. The second surface coil includes means for detuning that coil except when an externally-provided signal is present; this signal may be the RF excitation signal itself or another signal provided simultaneously with the RF excitation signal.

BSPR:
Accordingly, it an object of the present invention to provide a novel NMR imaging antenna subsystem having a plurality of non-orthogonal, co-planar surface coils.

DRPR:
FIG. 2 is a schematic diagram of a substantially co-planar NMR surface coil antennae subsystem having a plurality of non-orthogonal surface coils, in accordance with the principles of the present invention;

DRPR:
FIG. 4 is a photograph illustrating an image of the ocular area of a human volunteer, obtained with the novel surface coil antenna subsystem of the present invention.

DEPR:
Referring now to FIGS. 2 and 3, a surface coil antennae subsystem 20 or 20' comprises at least two separate surface coils, such as first surface coil 21 and second surface coil 22. The surface coils may be formed upon a suitable insulative substrate 20'a, which may have flexibility properties tailored to allow the co-planar surface coils 21 and 22 to be contoured to the exterior surface of a sample to be investigated by NMR experiments. Each surface coil 21 or 22 is formed of a plurality N of segments, with the respective surface coil conductor segments 23 or 24 having straight, angulated or continuously curved peripheries, as shown by the angulated segments 23a-23h of the octogonal-shaped first, outer surface coil 21 (with N=8) or the continuously-curved arcuate segments 24a-24d of the second, inner surface coil 22 (with N=4). Advantageously, for use with first surface coil 21 acting as an exciting transmission antenna for a nuclei specie providing a re-radiated signal received by second surface coil 22, the average equivalent radius R of the larger surface coil will be at least twice the average equivalent radius r of the smaller surface coil 22.

DEPR:
Each of the N surface coil segments 23 or 24 has the ends thereof separated from the adjacent ends of other segments 23 or 24 of the like surface coil. That one of coils 21 and 22 intended for use as a reception coil has one of a plurality N of capacitive coupling elements coupled across each of the N gaps between adjacent segments thereof; thus, reception coil 22 has (N=4) coupling capacitors 25a-25d individually coupled between adjacent ends of different ones of the N=4 segments 22a-22d. Each of capacitors 25 is advantageously of variable value, selected to resonantly-tune the coil 22 to the Larmor frequency of the nuclei to be investigated. A plurality of capacitive elements is desirable to negate the effects of the parasitic capacitances 26a-26d, which are themselves capable of random variations. The received signal is

provided between coil ends 22a and 22b to connector 22

DEPR:
The surface coil intended for use as an excitation coil has one of a plurality M=(N-1) of capacitive element 27a-27g individually connected across all but one of the intersegment gaps. Thus, each of coupling elements 27a-27g is connected across one of the gaps between the adjacent ends of respective segments 23a-23h of coil 21, except for the gap between adjacent ends of segments 23a and 23h. An additional, or N-th, equivalent capacitive element, e.g. capacitive element 27h (shown in broken line), may be provided only by the parasitic capacitance of a first switching means 28. Capacitances 27 may be fixed or variable and are selected to tune, when means 28 provides a substantially low-impedance, e.g. short, circuit between the ends of segments 23a and 23h, the coil to the desired excitation frequency, in conjunction with the second coil segment parasitic capacitances 29a-29h. Each parasitic gap capacitance 27 is preferably of relatively small value, to detune the large surface coil away from the desired frequency when means 28 is in a non-conductive (high impedance, or open circuit) condition.

DEPR:
Means 28 can be any selective-conduction network, such as is illustratively provided by unidirectionally-conducting elements 28a and 28b. Elements 28a and 28b can be a pair of anti-parallel-connected diodes, if the magnitude of the RF excitation signal voltage expected across the diodes is sufficiently large and the diode speed is sufficiently fast to cause each diode to conduct for an appreciable portion of an RF signal half-cycle. As it is one continuing objective of NMR research to reduce the magnitude of the RF excitation signal used in in vivo experiments, certain excitation sequences or power levels may be of inadequate magnitude to cause diodes 28a and 28b to be rendered self-conductive during the excitation portion of an imaging sequence. An alternative selective-conduction network 28' may then be required, to provide a low-impedance condition between the ends of two adjacent segments, during excitation signal transmission and to provide a high-impedance condition at other times. If network 28' is present, means 28 and capacitance 27b are removed and capacitance 27h is provided. Means 28' utilizes a pair of RF switching elements 28' a and 28'b, which may be of the voltage-controlled type, such as varactor diodes and the like, or may be of the currentcontrolled type, such as P-I-N diodes and the like, to provide the required low-impedance connection between the two adjacent ends of a chosen pair of segments, e.g. segments 23b and 23c in the illustrated example, responsive to an external signal, e.g. switching signal V.sub.s, which is provided at least during each time interval when an excitation signal is applied to the surface coil ends 21a and 21b, via connector 21c. Illustratively, means 28' has a pair of P-I-N diodes 28'a and 28'b in series-connection between the ends of segments 23b and 23c; the common cathodes of the two diodes are returned to D.C. common potential through a first RF choke coil 28'c, while each diode anode is connected via another RF choke 28'd or 28'e to a positive switching control voltage V.sub.s input 28'f. If use of a negative V.sub.s input voltage is desired, the polarity of both diodes 28'a and 28'b must be reversed. In either case, it will be seen that, in the absence of signal V.sub.s, the diodes are in an essentially non-conductive condition and, as capacitance 27b is then only the small parasitic capacitance of the non-conducting diodes, the larger surface coil 21 is not resonant and does not appreciably couple to the smaller surface coil 22. When signal V.sub.s is present, a low impedance appears between the ends of segments 23b and 23c, effectively completing the coil; the capacitances 27a, 27c-27h and 29a-29h tune the now-complete coil to resonance at the Larmor frequency of the excitation signal.

DEPR:
Means 30, present across one intersegment gap of each surface coil used for signal reception, provides a parallel-resonant "trap" circuit, for detuning the reception surface coil and substantially preventing the presence of excitation-frequency signals at the reception surface coil output, response to induction of a signal in the reception surface coil at the resonant Larmor frequency of the trap circuit. Means 30' provides the same "trap" action, responsive to an external signal, as an alternative to means 30. Thus, reception surface coil 22 has a detuning means 30 or 30' across the gap between two adjacent segments, e.g. between segments 24b and 24c or between segments 24c and 24d. Means 30 includes an induced-signal sensing means, such

as anti-parallel-connected diodes 30a and 30b, for providing a low-impedance circuit only if a signal of sufficiently hazardous magnitude (e.g. greater than some few tenths of a volt, peak) is induced in surface coil 22. Means 30 also includes a reactive element which is switched into parallel connection across the gap responsive to the low-impedance condition obtaining in the sensing diodes 30a and 30b; this reactance is of opposite sign to the reactance of the tuning element across the same intersegment gap, and of a value selected to parallelly resonate with the intergap impedance at the Larmor frequency of an associated excitation surface coil antenna. Means 30' utilizes an externally-controlled detuning means, e.g. a P-I-N diode 30'a, which is in RF series-connection with reactive element 30'c across capacitance 25a; a pair of RF chokes 30'd and 30'e are effectively in series with the diode between ground potential and an input terminal 30'f, to allow the diode to conduct (and place element 30'c across capacitor 25a) responsive to an externally-supplied signal, e.g. a voltage +V, being provided at input terminal 30'f. Thus, where (as illustrated) the tuning impedance element across the associated gap is a capacitance 25c or 25a, the impedance element 30c or 30'c is an inductance, of value L aproximately given by: L=(2.pi.f.sub.L).sup.-2 /C, where f.sub.L is the Larmor frequency to be excited by the associated excitation surface coil 21 and C is the value of capacitor 25c or 25a. Inductor 30c or 30'c will advantageously be of a value and position such that it has minimal coupling to either reception or excitation surface coils; a toroidal inductor or an inductance formed by a shorted length of coaxial cable, is preferred for avoiding this undesired inductive coupling. It will be understood that the actual value of both capacitor 25c or 25a and inductor 30c or 30'c must be adjusted in situ, respectively, with no excitation present and with excitation present in coil 21, to account for the effects of parasitic impedance of the non-ideal diodes used for switching elements 30a and 30b or element 30'a. Similarly, the value of at least one of capacitances 27 of excitation coil 21 may require adjustment due to the parasitic impedance of the non-ideal switching diodes 28a and 28b, 28'a and 28'b or 30'a. It should also be understood that if surface coils for several different frequencies are "stacked" (as described in the abovementioned co-pending application) to allow simultaneous or sequential NMR experimentation with different species of nuclei, then each coil (either excitation or reception) may require a parallel-resonant trap circuit for each of the total number of involved Larmor frequencies, to prevent induced effects between the various coils if the coil locations and Larmor frequencies are such that coupling is possible. Such additional traps can be provided by one or more additional inductances 32a-32d, each in parallel connection with an associated one of capacitors 27a, 27c, 27e and/or 27g and tuned to the required frequency. Either or both of coils 21 and/or 22 can have additional trap circuits; the values of capacitance in parallel with each trap inductance 32 may, but need not, be of similar magnitude and the value of those capacitors not bridged by a trap inductance can be the same as, or different than, both the trap capacitors, or each other. In generally, similar values may be used to provide a symmetrical radiation/sensitivity pattern to each surface coil antenna, although it should be understood that some NMR experiments may require use of non-identical impedances in any of impedance elements 25, 27, 30 and/or 32, to obtain a particular required antenna characteristic.

DEPR:
Referring now to FIG. 4, a photograph of a .sup.1 H image of an axial section of a human volunteer, as imaged with a surface coil subsystem in accordance with the present invention, is shown. The clarity of the details of the human eye and brain, in this 4 mm. thick slice, illustrate the substantial non-interaction of the co-planar antennae of the present invention. The imaging antenna subsystem comprised a single-loop reception coil 22, of about 5 centimeters median radius r, having an inductance of about 190 nanohenries and four segments 24; four capacitors 25 of about 130 picofarads each were used, for .sup.1 H imaging at a Larmor frequency of about 63.5 MHz. in a system having a static field B.sub.O of about 1.5 Tesla. Diodes of the 1N4608-type were used, with a two-turn, 12 millimeter diameter inductance 30c, positioned such that its axis was substantially perpendicular to the common plane of the surface coils. The excitation coil was of eight-segment octogonal shape, having a median spacing of about 25 centimeters between opposite sides and a loop inductance of about 60 nanohenries. Capacitors 27 were about 82 picofarads. Means 28 comprised a pair of Unitrode UM6201-B P-I-N diodes.

DEPR:
While several presently preferred embodiments of my novel NMR imaging antenna subsystem with a plurality of non-orthogonal surface coils have been described herein, many modifications and variations will now become apparent to those skilled in the art. For example, other non-orthogonal coil systems, such as one having a volume excitation coil and a surface reception coil, can be equally as well utilized with the detuning means of the present invention. It is my intent to be limited only by the scope of the appending claims and not be the specific details and instrumentalies presented by way of explanation and illustration herein.

CLPR:
1. An antenna subsystem for use in magnetic resonance imaging of selected nuclei in a sample, comprising:

CLPR:
2. The antenna subsystem of claim 1, wherein said externally-provided switching signal is the radio-frequency excitation signal itself.

CLPR:
3. the antenna subsystem of claim 2, wherein each excitation surface coil antenna comprises a conductive member having at least one gap formed therein; and said first means comprises: at least one switching element connected between adjacent conductive member ends defining a selected one of said at least one gap, the at least one switching element being (1) enabled to a relatively low impedance condition responsive to the presence of said externally-provided radio-frequency signal at said excitation surface coil and (2) disabled to a relatively high-impedance condition responsive to the absence of said externally-provided radio-frequency signal at said excitation surface coil antenna.

CLPR:
4. The antenna subsystem of claim 3, wherein said at least one switching element comprises a pair of antiparallel-connected diodes coupled across said selected gap.

CLPR:
5. The antenna subsystem of claim 1, wherein said externally-provided switching signal is a signal different from said radio-frequency excitation signal.

CLPR:
6. The antenna subsystem of claim 5, wherein each of said excitation surface coil antennae comprises a conductive member having at least one gap formed therein; and said first means comprises: at least one switching element connected across one conductive member gap and responsive respectively to the presence and absence of an electrical parameter for attaining respective low-impedance and high-impedance conditions; means for receiving the externally-provided switching signal; and means for connecting the switching signal receiving means to said at least one switching element to cause said switching element to switch between said low-impedance and high-impedance conditions responsive to selected ones of the presence and absence of said switching signal.

CLPR:
7. The antenna subsystem of claim 6, wherein said at least one switching element is at least one varactor diode and said switching signal is a switching voltage.

CLPR:
8. The antenna subsystem of claim 6, wherein said at least one switching element is at least one P-I-N diode and said switching signal is a switching current.

CLPR:
9. The antenna subsystem of claim 1, wherein a pair of non-orthogonal surface coil antennae are co-planar to one another.

CLPR:
10. The antenna subsystem of claim 9, wherein the centers of the pair of surface coil antennae are substantially identical.

CLPR:
11. The antenna subsystem of claim 9, further comprising an insulative substrate supporting said pair of surface coils upon a surface thereof.

CLPR:
12. The antenna subsystem of claim 1, wherein each of said plurality of surface coil antennae comprises; a plurality of conductive segments arranged with each of a like plurality of intersegment gaps between adjacent pairs of segments; and further including at least one reactive means coupled across at least one intersegment gap for tuning the associated surface coil antenna to the Larmor frequency of a nuclei species to be imaged with said subsystem.

CLPR:
13. The antenna subsystem of claim 12, wherein at least one of the at least one reactive means is a variable reactance.

CLPR:
14. The antenna subsystem of claim 13, wherein the variable reactance is a variable capacitive reactance.

CLPR:
15. The antenna subsystem of claim 12, wherein said at least one reactive means is a capacitive element.

CLPR:
16. The antenna subsystem of claim 15, wherein an inductive element is coupled in parallel with at least one of the capacitive elements, the inductive element having an inductive reactance selected to resonate with the reactance of the associated capacitive element at a predetermined frequency.

CLPR:
17. The antenna subsystem of claim 16, wherein the predetermined frequency is different than the Larmor frequency to which the surface coil antenna is tuned.

CLPR:
18. The antenna subsystem of claim 1, wherein each signal reception antennae comprises a conductive member having at least one gap formed therein; and said second means comprises: an element of a first impedance type connected across said gap; an element of a second impedance type, of magnitude selected to resonate with said first impedance element at the Larmor frequency of the signal provided to the associated excitation antenna; and means, connected in series with said second impedance element across said gap, for selectively connecting said second impedance element in parallel with said first impedance element responsive only to said radio-frequency signal induced in said reception antenna.

CLPR:
19. The antenna subsystem of claim 18, wherein said first reactive element is a capacitive element; and said said second reactive element is an inductive element.

CLPR:
20. The antenna subsystem of claim 19, wherein said connecting means comprises a pair of unidirectionally-conducting switching elements coupled in antiparallel connection between one gap-forming end of said conductive member and that end of said second impedance element furthest from the end thereof connected to the other gap-forming end of said conductive member.

CLPR:
21. The antenna subsystem of claim 19, wherein said connecting means comprises: at least one switching element coupled between one gap-forming end of said conductive member and that end of said second impedance element furthest from the end thereof connected to the other gapforming end of said conductive member and responsive to the presence or absence of a control

signal for providing an associated low-impedance or high-impedance condition between said ends; and means for providing said control signal to said switching element from a source external to said antenna subsystem.

CLPV:
a plurality of substantially planar surface coil antennae disposed with the planes thereof in a non-orthogonal registered relationship;

CLPV:
first means, forming a portion of each of said surface coil antennae to be uitlized for sample excitation with an externally-provided radio-frequency (RF) excitation signal, for causing the associated surface coil antenna to be resonant, at the Larmor frequency of the selected nuclei, responsive only to an externally-provided switching signal; and

CLPV:
second means, forming a portion of each of said surface coil antennae to be utilized for response signal reception, for detuning the associated surface coil antenna at least when a radio-frequency signal is induced therein by the RF excitation signal in one of said excitation antennae.

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☐ 1. Document ID: US 6255817 B1

L20: Entry 1 of 3 File: USPT Jul 3, 2001

US-PAT-NO: 6255817
DOCUMENT-IDENTIFIER: US 6255817 B1

TITLE: Nuclear magnetic resonance logging with azimuthal resolution

DATE-ISSUED: July 3, 2001

INVENTOR-INFORMATION:

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US-CL-CURRENT: 324/303; 324/300

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 2. Document ID: US 5396174 A

L20: Entry 2 of 3 File: USPT Mar 7, 1995

US-PAT-NO: 5396174
DOCUMENT-IDENTIFIER: US 5396174 A

TITLE: Antenna arrangement with shielding for a nuclear magnetic resonance tomography apparatus

DATE-ISSUED: March 7, 1995

INVENTOR-INFORMATION:

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US-CL-CURRENT: 324/318

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw Desc | Image

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☐ 3. Document ID: US 5050605 A

L20: Entry 3 of 3 File: USPT Sep 24, 1991

US-PAT-NO: 5050605
DOCUMENT-IDENTIFIER: US 5050605 A

TITLE: Magnetic resonance imaging antennas with spiral coils and imaging methods employing the same

DATE-ISSUED: September 24, 1991

INVENTOR-INFORMATION:

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US-CL-CURRENT: 600/422; 324/318, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference   KWIC | Draw. Desc | Image

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L20: Entry 3 of 3 File: USPT Sep 24, 1991

DOCUMENT-IDENTIFIER: US 5050605 A
TITLE: Magnetic resonance imaging antennas with spiral coils and imaging methods employing the same

ABPL:
An antenna structure for magnetic resonance imaging includes a plurality of spiral wound, generally planar coils spaced axially from one another. The plural coils may be mounted on a rigid frame in the desired relative positions and the subject may be inserted in the space defined by the frame. Alternatively, the individual coils can be separately supported on the subject, as by mounting the coils to the subject. Desirably, a part of the subject's body extends through central apertures in one or more of the coils.

BSPR:
The present invention relates to the art of magnetic resonance imaging, also referred to as nuclear magnetic resonance imaging.

BSPR:
Magnetic resonance imaging or "MRI" provides images of internal structures of a subject without the need for X-rays or other invasive techniques. Magnetic resonance imaging uses the phenomenon referred to as nuclear magnetic resonance. Certain atomic nuclei have spins. In the presence of a strong magnetic field, these spins tend to align themselves in the direction of the magnetic field. Upon exposure to radio waves having particular frequency, referred to as the resonant or Larmor frequency, the vectors of the nuclei are displaced out of alignment with the applied magnetic field. After such displacement, the spins of the nuclei turn or "precess" around the direction of the applied magnetic field. As each spin turns, the nucleus creates an infinitesimal radio signal, referred to herein as a "magnetic resonance signal", also at the resonant or Larmor frequency. The precessing spins gradually drift out of phase with one another, and gradually drift back into alignment with the direction of the applied magnetic field. Therefore, the magnetic resonance signals gradually decay. Certain parameters of the magnetic resonance signals vary with the chemical and physical state of the matter being studied.

BSPR:
In magnetic resonance imaging, the properties of magnetic resonance signals from individual small volume elements or "voxels" within a larger subject are determined. This permits generation of an image such as a pictorial image representing individual volume elements having differing chemical and/or physical properties in contrasting shades. Because the magnetic field and exciting radio frequency signal typically are applied to a sizable region of the subject, far larger than each individual volume element, it is necessary to apply some technique for identifying the magnetic resonance signals from different volume elements. Techniques for encoding magnetic resonance signals spatial information and determining the magnetic resonance parameters of individual volume elements from signals representing many volume elements are complex and beyond the scope of this disclosure. However, these techniques are well known to those in the magnetic resonance imaging arts.

BSPR:
Because MRI can generate images based on chemical and physical variations in the body of the subject, magnetic resonance imaging can depict essentially any tissue in a living subject such as a human. MRI does not rely upon absorption

of X-rays or other ionizing radiation by the body tissue. Moreover, MRI can detect abnormalities which are extremely difficult or impossible to detect by other techniques. Therefore, MRI has been widely adopted in the medical profession.

BSPR:
The magnetic resonance signals generated by the subject are extremely weak. To obtain a useful image, these signals must be received and distinguished from background electromagnetic noise. Typically, the magnetic resonance signals are converted to electrical impulses by an antenna and conveyed to the preamplifier of a radio frequency receiver adapted to amplify and detect signals at the resonant frequencies of interest. The information recovered by this receiver is conveyed to known devices for digitizing the signals and processing the digitized signals to recover the image. The quality of the image is directly related to the quality of the receiving antenna. One measure of antenna quality is sensitivity, i.e., the signal voltage generated in the receiving antenna by magnetic resonance signals of a particular magnitude. The higher the sensitivity within the region to be imaged, the weaker the signals which can be detected. Desirably, the sensitivity of the antenna is substantially uniform with respect to magnetic resonance signals emanating from all volume elements within the region of the subject which is to be imaged. Another measure of antenna quality is signal to noise ratio, i.e., the ratio between those components in the electrical impulses appearing at the antenna terminals representing the desired magnetic resonance signals to the components representing spurious electromagnetic signals in the environment. To optimize the signal to noise ratio, the antenna should have low sensitivity to signals from outside the region to be imaged. To enhance both signal to noise ratio and sensitivity, the antenna should be "tuned" or arranged to resonate electrically at the frequency of the magnetic resonance signals to be received, typically several megaHertz or more. As further discussed below, this implies certain limits on the electrical characteristics of the antenna such as its inductance and capacitance.

BSPR:
Moreover, the antenna should be compatible with the physical requirements of the system. The magnet assemblies employed to generate the magnetic field applied to the subject typically provide relatively small spaces for receiving the subject within the magnet assembly. The receiving antenna must fit within this limited space together with other components of the system and the subject. The receiving antenna should not impose any particularly difficult physical constraints on the subject. In the case of a human or animal subject, the antenna should not cause significant discomfort to the subject. Additionally, the antenna structure should be easy to use and relatively insensitive to minor faults in positioning relative to the subject. These numerous considerations often conflict with one another and together present a formidable problem.

BSPR:
Substantial efforts have been made heretofore in design of magnetic resonance imaging antennas. As disclosed, for example, in Sobol, "Dedicated Coils in Magnetic Resonance Imaging", Reviews of Magnetic Resonance in Medicine, Vol 1, No. 2, pp. 181-224, 1986, certain electrical properties such as the pattern of sensitivity for a particular antenna can be calculated with reasonable accuracy from mathematical treatment of the parameters describing antenna design after the design has been specified. The same properties can be measured experimentally after the antenna has been built. As further discussed in the same article, the antenna configurations which have been tried include single flat loops of conductive wire, dual loops coaxial with one another and spaced apart along their common axis, commonly referred to as a Helmholtz pair, solenoidal or helical coils and saddle-shaped coils. Some of these coils are mounted to the magnet structure so that the coil is adjacent the patient receiving space of the magnet structure and receives signals from substantially the entire patient receiving space. Thus, saddle-shaped coils can be mounted within a cylindrical bore of a typical cylindrical, air core solenoid magnet structure used in some MRI equipment.

BSPR:
Other surface coils have been made in the form of small, generally planar wire loops such that the entire loop can be arranged on the patient's body surface

in an area overlying [illegible] anatomical feature of interest[illegible]n such an arrangement, the looplike coil lies substantially in the plane of the body surface. Although coils of this nature provide useful signals for imaging structures lying close to the skin, they suffer from a very significant drawback in that their sensitivity decreases dramatically with distance from the plane of the coil loop. Thus, this type of surface coil is essentially useless for imaging structures deep within the body.

BSPR:
Brown, M.E. et al., The Design Construction and Evaluation of Receiver Coils for Specific MR Imaging Application, in the Book of Abstracts, Fifth Annual Meeting, Society of Magnetic Resonance in Medicine, Addenda, Works-in-Progress, pp 43-44, 1986, mentions an antenna structure including two spiral coils spaced axially from one another. These coils are spaced from one another so that small body parts such as hands and ankles can be inserted in the gap between the two spaced coils. The dual-coil design is expressly characterized in this article as limited to imaging of small body parts.

BSPR:
Accordingly, despite all of the effort expended heretofore in development of MRI receiving antennas, there are still considerable unmet needs for further improvements in MRI receiving antenna structures and in methods of using the same.

BSPR:
The present invention addresses these needs. One aspect of the present invention provides a receiving antenna for a magnetic resonance imaging system. An antenna according to this aspect of the present invention includes a first spiral coil having an axis and having radial directions transverse to the axis. The first spiral coil desirably has an aperture adjacent the axis and a plurality of turns of progressively varying radial extent encircling the aperture. Thus, the first spiral coil may include an innermost turn closest to the axis, and hence closest to the aperture, and may also include one or more outer turns at progressively greater distances from the axis and aperture. The antenna desirably also includes means for positioning the first spiral coil adjacent the body of a subject to be imaged so that the body part extends through the aperture and the turns of the first spiral coil encircle the body part. Thus, the outer turns having progressively larger radial extent will be disposed at progressively greater distances from the surface of the encircled body part. The antenna desirably includes means for connecting the first spiral coil to an input of a radio receiver.

BSPR:
The antenna may further include additional antenna elements such as a second spiral coil and optionally a third spiral coil. Still further additional antenna elements may be included.

BSPR:
Positioning means may include a frame and both of the coils may be mounted to the frame so that the frame holds the coils in substantially predetermined spatial relationship to one another. The coils and the frame may cooperatively define a structure having a patient receiving space between the coils. The aperture in the first may provide an opening for insertion of the body part into the patient receiving space of the structure. Desirably, the frame is arranged so that the axes of the coils are substantially parallel to one another and so that the coils substantially overlie one another but are spaced apart from one another in their respective axial directions. Alternatively, each of the plural spiral coils may be provided with separate fixtures for supporting the coils on the body of the subject, and thus maintaining the coils in the desired spatial relationship to one another. The second spiral coil may have an aperture adjacent its axis such that the turns of the coil encircle the aperture, and the apertures in the second coil may define one or more of the openings in the coil and frame structure. The apertures in the coils may be aligned with one another, so that an elongated body part may extend through the aligned apertures. Additional openings may be provided by openings in the structure adjacent one of the coils, such as axial gaps between the coils. Alternatively, the additional antenna element or second coil may have structures such as inner turns disposed adjacent its axis, so that this structure or inner turns of the second coil may be aligned with the

axis and aperture in the first coil. In use, the additional antenna element may overlie an end or distal surface of a body part which extends through the aperture in the first coil.

BSPR:
A further aspect of the present invention provides methods of magnetic resonance imaging including the steps of providing an antenna including first spiral coil as aforementioned, positioning this spiral coil adjacent the body of a subject to be imaged so that a body part of the subject extends through the aperture in the first coil and the turns of this coil encircle this body part. Desirably, the method further includes the step of positioning one or more additional antenna elements such as further spiral coils adjacent the body of the subject and within interactive range of the first coil. As further discussed hereinbelow, plural antenna elements may be said to lie in interactive range of one another when they are close enough to one another such that there is substantial interaction between each coil and the magnetic field from the other coil. Most preferably, the positioning step is performed so that the axes of plural spiral coils lie substantially parallel to one another and so that the coils overlap one another. Thus, the plural spiral coils may be positioned substantially coaxial with one another. The positioning step may be performed by mounting the spiral coils to the body surface of the patient or else may be performed by positioning the appropriate region of the patient in the patient receiving space of a coil and frame structure as mentioned above.

BSPR:
The method further includes the steps of exciting nuclear magnetic resonance in the body of the subject and receiving magnetic resonance signals from the subject by way of the coil or coils and reconstructing an image of at least a part of the body of the subject from the received resonance signals.

BSPR:
Preferred methods and apparatus according to the present invention provide unique combinations of high sensitivity and high signal to noise ratio with deep penetration, i.e., with good sensitivity to magnetic resonance signals from regions deep within the body. Moreover, preferred methods and apparatus according to the present invention provides antenna structures and methods of using the same which are versatile in that they can be applied to almost any area of a typical subject. Additionally, the structures and methods according to preferred embodiments of the present invention provide these enhanced results while maintaining practical values of antenna inductance and capacitance, thereby facilitating tuning of the antenna to the resonant frequency. Further, preferred structures and methods according to these aspects of the present invention combine these desirable results with excellent convenience in use and with excellent patient comfort.

DRPR:
FIG. 1 is a schematic view depicting an antenna in accordance with one embodiment of the present invention, in conjunction with a subject to be imaged and with other elements of a magnetic resonance imaging system.

DRPR:
FIG. 3 is a schematic perspective view depicting an antenna in accordance with a further embodiment of the invention.

DRPR:
FIG. 4 is a schematic sectional view taken along lines 4--4 in FIG. 3, but showing the antenna in conjunction with a subject.

DRPR:
FIGS. 5 and 6 are schematic sectional views depicting antennas in accordance with further embodiments of the invention.

DRPR:
FIG. 7 is a schematic sectional view showing the antenna of FIG. 6 in a different position relative to the subject.

DRPR:
FIG. 8 is a schematic perspective view depicting an antenna in accordance with

yet another embodiment of the invention.

DEPR:
An antenna in accordance with one embodiment of the present invention includes a first spiral coil 10. Coil 10 includes a single metallic conductor 12 which in this case is a copper strip disposed on a sheetlike polymeric support. The conductor 12 extends through three turns 14, 16 and 18 around a central axis 20. Turns 14, 16 and 18 are of progressively varying size or extent in the radial directions transverse to axis 20. Thus, turn 14 is the radially innermost turn, lying closer to axis 20 than any of the other turns 16 and 18, whereas turn 16 is an intermediate turn and turn 18 is the radially outermost turn, lying at the greatest radial distances from the axis. The innermost turn 14 lies at a substantial distance from axis 20 and hence defines an aperture 21 inside the innermost turn and encompassing axis 20. Coil 10 defines a generally spiral shape in the sense that its turns are of progressively increasing radial extent. Each portion of turn 16 is disposed at greater radial distance from axis 20 than the corresponding portion of coil 14 and likewise each portion of outermost turn 18 is disposed at a greater radial distance from axis 20 than is the corresponding portion of intermediate turn 16. As used in this disclosure, the term "spiral" as used with reference to a coil should be understood as encompassing a coil having this geometric property of progressively varying radial extent on successive turns regardless of whether the dimensions in the radial direction vary monotonically or continuously along the length of the conductor.

DEPR:
As further discussed hereinbelow, the radial extent of a coil can be significant in describing the spacings and functions of the coil. One such measure of the radial size of a spiral coil is the mean outer radius, the average value of the radial distance for the outermost turn. Another useful measure is the mean radius of the coil, i.e., the mean of radial distance for all points on the conductor constituting the coil, over all of the turns. As seen in FIG. 2, coil 10 lies in or close to a plane transverse to the central axis 20. The term "generally planar" as used in this disclosure with reference to spiral coils refers to a coil in which the axial extent of the coil--the maximum distance parallel to the axis of the coil between any two points on the conductor--is less than about 25% of the mean outer radius of the coil. Coils intended to encircle a part of the subject desirably are as close to planar as is practicable, and hence may have a maximum axial extent less than 10% and in some cases less than 5% of the outer radius.

DEPR:
Coil 10 is mechanically fastened on a ring-shaped pad 22 of an electrically non-conductive, relatively soft foam material attached to support 13. Pad 22 extends radially inwardly slightly beyond the radially innermost margin of support 13, and hence extends radially inwardly into aperture 21. The antenna further includes a second spiral coil 24. Coil 24 is substantially identical to coil 10. Coil 24 defines a central aperture 25 and is attached to a ringlike foam pad 26 protruding slightly into aperture 25.

DEPR:
Additionally, the antenna includes leads 28 and 30 connected to the innermost and outermost ends respectively of first coil 10 and leads 32 and 34 connected to the innermost and outermost ends respectively of second coil 24. The leads are connected to one another and to connectors 36 and 38 so that coils 10 and 24 are in parallel with one another across connectors 36 and 38. The pattern of interconnection of the leads and connectors is selected so that when the coils 10 and 24 are positioned with the associated foam pads 22 and 26 toward one another (as seen in FIGS. 1 and 2) current passing from connector 36 to the connector 38 will flow either clockwise or counterclockwise in both coils, as viewed by an imaginary observer at a common reference point P.sub.r on axis 20 outside of the gap 39 between the two coils. For example, current passing from connector 36 to connector 38 will pass counterclockwise in each of coils 10 and 24 as seen by an imaginary observer at point PR. The term "connected for codirectional current flow" is used in this disclosure as referring to plural coils interconnected so as to meet this condition. As will be appreciated, it is not necessary that the directions of windings of the plural coils be the same as one another in order for the plural coils to be interconnected for codirectional flow. Merely by way of example, if the

direction of winding one of the coils 10 or 24 were reversed, that reversed coil could still be interconnected for codirectional current flow with the other if the leads extending to one coil were modified to reverse the leads as between the innermost and outermost ends of the coil.

DEPR:
A capacitor 40 is connected across connectors 36 and 38, and hence in parallel with the parallel connected coils 10 and 24. Connectors 36 and 38 are arranged to mate with the input signal and ground connectors 42 and 44 of a radio signal receiving section 51 of a magnetic resonance imaging unit 50. Although leads 28-34 and capacitor 40 are depicted and referred to separately for clarity of illustration, it should be appreciated that all or a portion of the capacitance 40 in parallel with the coils may be contributed by parasitic capacitances of the coils themselves and/or capacitance in the leads 28-34. Desirably, leads 28 and 30 are constituted of a single coaxial cable, whereas leads 32 and 34 are formed as another coaxial cable to minimize the effects of stray electromagnetic radiation on the leads. In this arrangement particularly, there may be substantial capacitance between the leads.

DEPR:
The antenna is employed in conjunction with a magnetic resonance imaging apparatus 50. Imaging apparatus 50 may include a radio signal receiver 51 including a preamplifier 52 for receipt and amplification of magnetic resonance signals in the form of electrical voltages and a further analog signal processing section 54 adapted to take the amplified signals from preamplifier 52. Analog signal processing section 54 may include conventional amplification, filtering and demodulation and/or mixing devices. The MRI unit 50 further includes a digitizer 56. Digitizer 56 is adapted to convert the magnetic resonance signals processed by analog signal processor 54 into digital form. The output of digitizer 56 is connected to the input of an averager 58 arranged to average a plurality of digitized signals. The imaging apparatus may further include an image reconstruction computer 60 arranged to derive an image from the signals averaged by averaging unit 58. Image reconstruction unit 60 is linked to a display and output unit arranged to show the image in a human-readable form such as a pictorial display and also to output the image to appropriate storage or communications devices (not shown).

DEPR:
Additionally, the magnetic resonance imaging unit 50 includes a static magnetic field application unit 63 which incorporates a large magnet 64, schematically and fragmentarily illustrated in FIG. 1. Magnet 64 defines a patient receiving space 66, the magnet being adapted to apply a substantially uniform static magnetic field B.sub.O within space 66. Space 66 is large enough to receive at least a portion of a typical human body, preferably large enough to receive the torso and/or the head of a typical human subject. Additionally, the magnetic resonance imaging unit 50 includes a magnetic field gradient coils 68, of which only one is shown in FIG. 1. Typically, three sets of coils are mounted adjacent the patient receiving space 66 of magnet 64, the different sets of coils being arranged on different geometric axes. A field gradient application control unit 70 is provided for selectively energizing the various sets of gradient coils 68 to impose magnetic field gradients or variations in the magnitude of magnetic field B.sub.O on any one or more of the three coordinate axes X, Y and Z. Field gradients can be provided in directions oblique to these axes by preapplying gradients on two axes simultaneously.

DEPR:
Magnetic resonance imaging unit 50 further includes an excitation radio frequency transmitter 72 connected to a transmitting antenna 74 disposed adjacent patient receiving space 66 of magnet 64. All of these components in MRI scanning unit 50 are connected to a control and power supply unit 76 adapted to energize and control all of these components. Typically, the control and power supply unit incorporates a programmed, general purpose digital computer.

DEPR:
The components of MRI scanning unit 50 are conventional and well known, and hence will not be described in detail in this disclosure. Suitable MRI units

are made and sold commercially under the trademarks FONAR, BETA 3000 and BETA 3000M by the Fonar Corporation of Melville, N.Y.

DEPR:
In this regard, it is not essential that the axes of the coils be exactly parallel or coincident. However, the coils should be arranged in substantially overlapping disposition. As used in this disclosure, a first coil and a second coil may be said to substantially overlap one another if the areas enclosed by their outermost turns, projected parallel to the axis of the first coil into a plane perpendicular to the axis of that coil would intersect one another greater than about 50% of the projected area of the first coil. For example, in the embodiment of FIGS. 1 and 2, the entire area enclosed by the outermost turn of first coil 10 and second coil 24, if projected along the common axis 20 into a common plane perpendicular to axis 20 would intersect. The coil arrangement thus tends to minimize stray capacitance between the coils and the subject's body. As best seen in FIG. 2, coils 10 and 24 are positioned such that the planes of the coils are substantially perpendicular to the adjacent portions of the patient's body surface. Thus, the innermost winding of each such coil is interposed between the outer windings and the patient's skin surface. In effect, the inner windings at least partially shield the subject's body from any electrostatic fields emanating from the outer windings. Further, the outer windings are spaced at greater distances from the patient's body surfaces. Thus, the windings of coils 100 and 102 do not appreciably interact electrostatically with the subject's body and hence do not add substantial stray capacitance to the antenna structure. The turns of each coil 10 and 24 desirably are constituted by thin, striplike metallic elements lying substantially in the plane of the coil and hence lying substantially in a plane perpendicular to the axis of the coil. Such thin, striplike elements may be formed, for example, by a common printed circuit techniques. Where such thin, striplike elements are employed, the capacitance of the coils with respect to the body surface is further limited in that the conductors lie substantially in a plane perpendicular to the body surface of the subject. This minimizes the area of the conductor constituting the innermost coil confronting the surface of the subject's body.

DEPR:
Moreover, the coils are disposed in interactive range of one another, i.e., close enough that there can be appreciable interactions between the two coils. As used in this disclosure, the statement that the two coils lie within interactive range of one another means that the center to center distance between the two coils is less than about 2 times the mean outer radius of the larger one of the two coils (or less than about 2 times the mean outer radius of each coil if both are equal). However, the two coils desirably are spaced apart from one another, so that the center to center distance is more than about 0.5 times the mean outer radius and preferably more than 1 times the mean outer radius.

DEPR:
The subject, and hence the coils supported on the subject are positioned in the patient receiving space 66 of the magnetic resonance imaging system, between the pole 64 of the static field application unit. Preferably, the subject, and hence the coils, are positioned so that the axes of the coils, on common axis 20, lie transverse to the direction the magnetic field vector B.sub.O of the magnetic field 63 generated by magnet 64. With the patient and coils so positioned, MRI unit 50 is actuated to conduct imaging routines in the normal manner. Thus, field gradient application unit 70 is operated to superimpose magnetic field gradients on the static magnetic field, whereas RF transmitter 72 is operated to apply radio frequency electromagnetic radiation to the subject at a frequency corresponding to the resonant or Larmor frequency of the atomic nuclei to be studied in the area of interest. Responsive to this radio frequency excitation, the atomic nuclei in the area of interest radiate electromagnetic radiation or magnetic resonance signals. The gradients applied by unit 70 and the frequencies applied by RF excitation unit 72 are selected according to well known and conventional techniques so that the magnetic resonance signals emitted by the atomic nuclei in the subject are spatially encoded, i.e., so that the information incorporated in the signals, together with information about the gradients and RF signals applied, is sufficient to permit identification of one or more parameters of the magnetic resonance response emanating from one or more particular elements

of volume V at known positions within the subject. Typ lly, but not necessarily, the spatial encoding is performed so that one or more parameters of the magnetic resonance response from a plurality of different volume elements can be identified.

DEPR:
The magnetic resonance signals emitted by the matter within the subject impinge upon the turns of coils 10 and 24, and induce potentials in these coils, which potentials are applied across the input terminals 42 and 44 of receiver preamplifier 52 in the magnetic resonance imaging system 50. These signals are processed in the conventional manner by system 50 to form an image of at least a portion of the subject. Where the spatial encoding process is conducted so that the received magnetic resonance signals incorporate information relating to a plurality of volume elements, the image typically is displayed as a pictorial representation of a magnetic resonance response parameter versus position. Such an image resembles a photograph of a cross section of the subject, except that the contrast or color variation represents differences in magnetic resonance response parameter rather than differences in optical parameters. Techniques for reconstructing images from magnetic resonance signals are well known and conventional, and accordingly will not be described in detail herein. Such techniques are described, inter alia. in the text NMR Imaging in Biomedicine, Mansfield and Morris, Eds., 1982, Academic Press, Inc.

DEPR:
Coils 10 and 24 cooperatively provide good sensitivity to magnetic resonance signals from all volume elements between the coils. Thus, for all volume elements disposed within the patient in the gap 39 between the planes of the coils and at a radial distance from axis 20 less than about 1-1.5 times the mean outside radius of the individual coils, magnetic resonance signals from these volume elements will produce appreciable voltages across input terminals 42 and 44. This is so even though the sensitivity for a single one of the two coils diminishes rapidly with distance in the axial direction away from the coil. Although the present invention is not limited by any theory of operation, it is believed that the particularly good spatial distribution of sensitivity in the axial direction results at least in part from an inductive coupling or "transformer" effect between the two coils.

DEPR:
The antenna as shown in FIGS. 1 and 2 provides good sensitivity even for signals emanating from volume elements adjacent axis 20, deep within the body part of leg P. Although the antenna as shown in FIGS. 1 and 2 has appreciable inductance, its inductance typically is less than the inductance of a solenoidal antenna which provides a comparable sensitivity distribution. The parallel connection of the spiral coils reduces the inductance of the antennas shown in FIGS. 1 and 2. By contrast, in an ordinary solenoidal antenna all of the turns are in series and hence their inductances are additive. The relatively low inductance of the antenna facilitates tuning to the desired resonant frequency. The resonant frequency f of a parallel-connected inductance L and capacitance C is given by the well-known formula: ##EQU1## Thus, the lower inductance values permit tuning to a relatively high frequency f even where irreducible stray capacitance implies a relatively high value of C. Notably, this system combines good sensitivity to the desired signals with good localization of the sensitive region. Thus, the antenna system has very low sensitivity to signals remote from the area between the coils. The sensitivity is well localized to a relatively small region of the subject encompassing the area of interest of the subject, between the coils. This materially aids in maintaining an acceptable signal to noise ratio. Further, the antenna system as shown in FIGS. 1 and 2 combines these benefits with ease of use and patient comfort. Thus, the coils positioned on the patient's leg do not create any significant discomfort. Also, the planar coils can be slipped over the distal end of the patient's limb without difficulty.

DEPR:
An antenna according to a further embodiment of the invention includes a first coil 100, second coil 104 and third coil 102 (FIGS. 3-5). Coils 100 and 102 are identical to one another. Each of these coils incorporates a conductor arranged to form two generally circular turns of gradually increasing radius. The innermost turn 106 has an substantial radius, and hence coil 100 defines a

large aperture 108 adjacent the axis 110 of the coil. Coil 100 is arranged on an annular electrically non-conductive, rigid thermoplastic ring 112. Ring 112 does not substantially occlude the aperture 108 defined by the coil. Coil 102 is likewise arranged on a similar ring 114.

DEPR:
Coil 104 incorporates four turns. The mean radius of the innermost turn 116 of coil 114 is considerably smaller than the mean radii of the innermost turns of apertured coils 100 and 102. Thus, coil 104 is an end coil having its innermost turn 116 close to the axis of the coil. Further, the mean outer radius of coil 104 is considerably smaller than the mean outside radii of coils 100 and 102. As illustrated, the mean outer radius of coil 104 is smaller than the radius of the apertures 108 and 118 defined by coils 100 and 102 respectively. Coil 104 is mounted on a rigid, electrically non-conductive plate 120. Plate 120 and rings 112 and 114 are interconnected by a plurality of support bars 122. Support bars 122, rings 112 and 114 and plate 120 cooperatively constitute a substantially rigid frame 123 which maintains coils 100, 102 and 104 in predetermined spatial relationship to one another such that the axes of all coils 100, 102 and 104 are substantially coincident on a common axis 110 and such that the coils are axially spaced from one another with third coil 102 lying axially between first or apertured coil 100 and third or end coil 104. Each pair of mutually adjacent coils 102 and 100 and 102 and 104 are within interactive range of one another. Moreover, all of the coils substantially overlap one another.

DEPR:
Bars 122 are spaced around the common coil axis 110 so that the frame is generally cage-like with significant open gaps between the rings and plates and between the bars 122. The frame 123, cooperatively with the coils thus forms an open structure having a patient receiving space 126 encompassing the common axis 110 in the region axially between the first apertured coil 100 and the second or end coil 104. A cushion formed from an electrically non-conductive, non-magnetic material such as a foamed plastic 128 is disposed within patient receiving space 126, bearing on rings 112 and 114 to one side of axis 110. A further, similar cushion 130 is disposed adjacent plate 120. These cushions are omitted from FIG. 3 for clarity of illustration.

DEPR:
Coils 100, 102 and 104 are connected in parallel with one another by coaxial cables 132 extending between these coils. Cables 132 incorporate substantial capacitance. The centrally disposed coil 102, and hence the other parallel-connected coils are connected to a pair of plugs 136 and 138, adapted for connection to the magnetic resonance signal inputs 42 and 44 of the MRI imaging unit 50 (FIG. 1). In a further method according to the present invention, a portion of a subject, such as the head of a patient P is positioned within the patient receiving space 126 defined by the antenna structure. The head is supported on cushions 128 and 130 and thus juxtaposed with the coils 100, 102 and 104 with apertured coils 100 and 102 encircling the head and end coil 104 confronting the top distal end surface of the head. Cushion 130 maintains cap coil 104 at a predetermined, small gap, typically about 1.0 cm., from the skin surface. Typically, the patient lies in a horizontal position as shown, so that the patient's head is supported by cushion 128. The antenna structure, and the other body portions of the patient, are supported on a conventional table (not shown) which in turn is inserted into the magnet 64 of the MRI imaging system (FIG. 1) so that the common coil axis 110 is transverse to the magnetic field vector B.sub.o . The magnetic resonance imaging apparatus is actuated as discussed above.

DEPR:
The coil assembly as discussed with reference to FIGS. 3 and 4 provides excellent sensitivity in the regions adjacent the common coil axis 110 over the axial region between coils 100 and 104. The sensitivity is especially good in the regions from cap coil 104 to a point about axially midway between coils 102 and 100. This distribution of sensitivity is particularly well matched to the requirements for MRI imaging of the brain and neighboring structures within the human head. Moreover, these results are provided in an antenna structure which still provides good levels of patient comfort. In particular, the gaps between the coils substantially avert the claustrophobic feeling associated with antenna structures which closely cover the head and which

provide at most relatively small gaps between antenna structures. Additionally, the relatively low inductance afforded by the spaced apart, parallel connected coils allows the antenna to be tuned to resonate at typical magnetic resonance frequencies with reasonable capacitance values, including substantial capacitance in coaxial cables 132. The ability to employ coaxial cables while still permitting proper tuning is advantageous because the coaxial cables are substantially immune to stray electromagnetic signals. As in the embodiments of FIGS. 1 and 2, the orientation of apertured coils 100 and 102 with their radial directions transverse to the adjacent surface of the patient's body minimizes stray capacitance between these coils and the skin.

DEPR:
The antenna structure shown in FIG. 5 includes three identical apertured coils 200 all aligned on a common axis 210. Each coil 200 is generally similar to one coil 10 of the structure depicted in FIGS. 1 and 2. However, each coil 200 incorporates three concentric windings. The coils are supported in predetermined positions relative to one another by a cage-like frame similar to the frame discussed above with reference to FIGS. 3 and 4 but incorporating three annular rings 212 and no end plate. The apertures defined by the coils and rings are mutually aligned with one another so that an elongated part of a subject piece such as the leg schematically shown can be inserted through at least one of the apertures into the tubular patient receiving space 226 defined by this antenna structure. Cushions 228 are disposed in the gaps between the coils. Structures of this nature are particularly suitable for imaging elongated subjects or parts of subjects such as the limbs of a living body. Antenna structures including three aligned coils provide a particularly good sensitivity distribution in the area encompassed by the coils 200 at the axial ends of the structure. The sensitivity distribution of a coil of this type is akin to that achieved by a long helical solenoid. However, the inductance of the antenna structure according to this aspect of the invention ordinarily is lower than a solenoid having comparable sensitivity and sensitivity distribution. Here again, the helical coils are connected in parallel to one another, thus minimizing the inductance of the structure. Also, the substantial gaps between the coils further tend to minimize the inductance of the structure of a whole.

DEPR:
As illustrated in FIG. 6, a further antenna structure includes two apertured coils 300 and a frame 323 including apertured rings 312 and bars 322. The central aperture 308 of at least one coil 300 is unoccluded. Further, the bars 322 are spaced apart from one another around the circumference of the annular rings and apertured coils. Therefore, a substantial L-shaped body structure such as a shoulder and upper arm may be positioned in the patient receiving space 326 of this antenna structure between the coils, with one branch (the shoulder blade) extending along the axis 310 of the coils and another branch (the upper arm) extending through the gap between the coils and between bars 322. This further illustrates the positioning versatility of coil arrangements according to this aspect of the invention. Further, the deep structures of the shoulder joint are disposed immediately adjacent the common axis 310 of the coils, and adjacent the midpoint of the gap between the coils. The antenna provides particularly good sensitivity for imaging these regions.

DEPR:
As shown in FIG. 7, the antenna structure of FIG. 6 can also be employed with a body part such as the shoulder of the patient protruding into patient receiving space 326 via the aperture 308 in one of the coils 300, but not protruding through any other aperture or gap in the antenna structure. Thus, the generally L-shaped shoulder can be positioned with both branches of the L extending through one aperture, as seen in FIG. 7. Although the plane of the coil is not perpendicular to the surface of the patient's body in the position of FIG. 7, the innermost turn 301 nonetheless lies closer to the body surface than does the outermost turn 303 of the same coil.

DEPR:
An antenna structure according to another embodiment of the invention, as shown in FIG. 8 incorporates two spiral coils 400 and 402 mounted on a generally L-shaped frame so that the planes of the two coils are substantially perpendicular to one another. The plate 408 of frame 406 which holds coil 400 is provided with an aperture 410 adjacent the axis of coil 400. A portion of

the patient's body such as the foot illustrated may be positioned through this aperture such that magnetic resonance signals from this portion of the patient's body will impinge upon both coils 400 and 402 and signals received by both coils will reinforce one another and add to the magnitude of the signals appearing at common terminals 412 and 414. Once again, coils 400 and 402 desirably are positioned within interactive range of one another as described above. However, the coils do not substantially overlap one another. This arrangement further illustrates the versatility of coil structures according to the broad compass of the present invention.

DEPR:
The antenna structures discussed above typically are made in sizes to fit the normal human anatomy, e.g., to fit the head or limbs of a human subject. However, the size of the antenna structure can be altered to suit other subjects. The features described above can be varied considerably within the broad scope of the invention. In an alternate arrangement, one or more of the spiral coils can be disconnected from the other coil and connected in an independent passive resonant circuit. Thus, in the arrangement of FIGS. 1 and 2 coil 24 can be disconnected from outputs 36 and 38, and hence disconnected from coil 10, and the disconnected coil 24 may be connected across a capacitor (not shown) selected to form, with coil 24, a circuit resonant at the frequencies of interest. In this arrangement capacitor 40 is exchanged for a larger capacitor so that the new capacitor forms a similarly resonant circuit with coil 10. Even though the second coil 24 is disconnected from antenna input terminals 42 and 44, the system still provides relatively good sensitivity. In particular, such an arrangement provides sensitivity at locations axially remote from coil 10 better than that achieved when coil 24 is simply removed from the system. This result suggests that a transformer effect or inductive coupling between the two coils does indeed enhance the uniform sensitivity of the system. However, optimum sensitivity is achieved when both coils are connected to the receiver terminals.

DEPR:
In the embodiments discussed above, the turns of each coil are constituted by a generally flat, striplike, metallic conductor lying substantially in the plane of the coil. Although such flat, striplike conductors are preferred for the reasons discussed above in most applications, other conductors may be employed. For example, the conductor may be a round, solid or tubular conductor.

CLPR:
1. A method of magnetic resonance imaging comprising the steps of:

CLPR:
2. A method as claimed in claim 1 wherein said antenna includes a second spiral coil also having an axis, having radial directions orthogonal to said axis and having a plurality of turns of progressively varying radial extent, the method of further comprising the step of juxtaposing said second spiral coil with the body of the subject within interactive range of said first spiral coil, said step of receiving said magnetic resonance signals including the step of receiving said signals through both of said coils.

CLPR:
12. A method as claimed in claim 2 wherein said juxtaposing steps include the step of juxtaposing said coils with the body so that said two coils are disposed at a center to center distance less than about one times the maximum radial extent of each of said two coils.

CLPR:
14. A receiving antenna for a magnetic resonance imaging system comprising:

CLPR:
15. An antenna as claimed in claim 14 further comprising a second spiral coil having an axis, radial directions transverse to the axis and a plurality of turns of progressively varying radial extent, said adapted for positioning further positioning said second spiral coil adjacent the body of the subject within interactive range of said first spiral coil.

CLPR:

16. An antenna as claimed in claim 15 further comprising means for electrically interconnecting said second coil and said first coil, said means for providing an electrical connection further connecting said second spiral coil to the radio receiver.

CLPR:
17. An antenna as claimed in claim 16 wherein said second coil has one or more inner turns adjacent its axis, the inner turns of said second coil being aligned with the aperture in said first coil.

CLPR:
18. An antenna as claimed in claim 17 further comprising a third coil defining an aperture aligned with said aperture of said first coil, said third coil being disposed axially between said first and second coils.

CLPR:
19. An antenna as claimed in claim 15 wherein said means adapted for positioning includes a frame, said coils being mounted to said frame so that said coils and said frame cooperatively define a structure having a patient receiving space between said coils, whereby the aperture in said first coil provides an opening for insertion of the part of a patient's body into said patient receiving space of said structure.

CLPR:
20. An antenna as claimed in claim 19 wherein the axes of said coils are substantially parallel to one another, said coils substantially overlapping one another and being spaced apart from one another in the axial directions of the coils.

CLPR:
21. An antenna as claimed in claim 20 wherein said coils are substantially coaxial with one another.

CLPR:
22. An antenna as claimed in claim 20 wherein said body part is elongated and said second coil has an aperture adjacent its axis, said apertures being aligned with one another, whereby the elongated part of a patient's body can be inserted through said aligned apertures.

CLPR:
23. An antenna as claimed in claim 22 further comprising a third coil mounted to said frame and axially spaced from said first and second coils, said

CLPR:
24. An antenna as claimed in claim 20 wherein said body part is generally L-shaped and said structure defines an intercoil opening between one said aperture coil and the adjacent coil, whereby said generally L-shaped region of the patient's body may be positioned in said structure with one branch of the L-shaped region extending through said aperture in the axial direction of said coils and another branch of said L-shaped region extending generally radially with respect to said coils through said intercoil space, and the juncture of these branches at the corner of the L-shaped region, being positioned within said patient receiving space adjacent to the axis of said coils and axially between said coils.

CLPR:
25. An antenna as claimed in claim 20 wherein said first coil is substantially planar, the plane of said first coil being substantially perpendicular to the axis of the coil.

CLPR:
26. An antenna as claimed in claim 15 wherein said means adapted for positioning said coils adjacent the body of the patient includes means for positioning said coils in a preselected orientation with respect to one another and further comprising means for electrically interconnecting said coils to one another so that upon passage of a current through each of said interconnected coils the resulting magnetic flux from one of said coils will reinforce the magnetic flux from the other one of said coils at least within a region of the subject's body disposed between said coils.

CLPV:
(a) providing an antenna including a first spiral coil having an axis, having radial directions orthogonal to said axis and including a plurality of turns of progressively varying radial extent, an innermost one of said turns defining an aperture surrounding said axis;

CLPV:
(b) juxtaposing said first spiral coil with the body of a subject so that a part of the body extends through said aperture, and the turns of said first spiral coil encircle said part of said subject's body whereby the turns of said first spiral coil having progressively larger radial extent are disposed at progressively greater distances from the surface of the encircled body part;

CLPV:
(c) extending nuclear magnetic resonance in the body of said subject;

CLPV:
(d) receiving magnetic resonance signals from said subject by means of said antenna; and,

CLPV:
(a) a first spiral coil having an axis, radial directions transverse to said axis, an aperture adjacent the axis and a plurality of turns of progressively varying radial extent encircling the aperture;

CLPV:
(b) means adapted for positioning said first spiral coil adjacent a part of the body of a subject to be imaged so that the body part extends through the aperture and turns of said first spiral coil encircle the body part whereby turns having progressively larger radial extent will be disposed at progressively greater distances from the encircled part; and,

CLPV:
(c) means for providing and electrical connections from said first spiral coil to a radio receiver.

ORPL:
Sobol, Wladyslaw, "Dedicated Coils in Magnetic Resonance Imaging", Reviews of Magnetic Resonance in Medicine, vol. 2, No. 2, pp. 181-224, 1986.